Instruments

THE MAGAZINE OF

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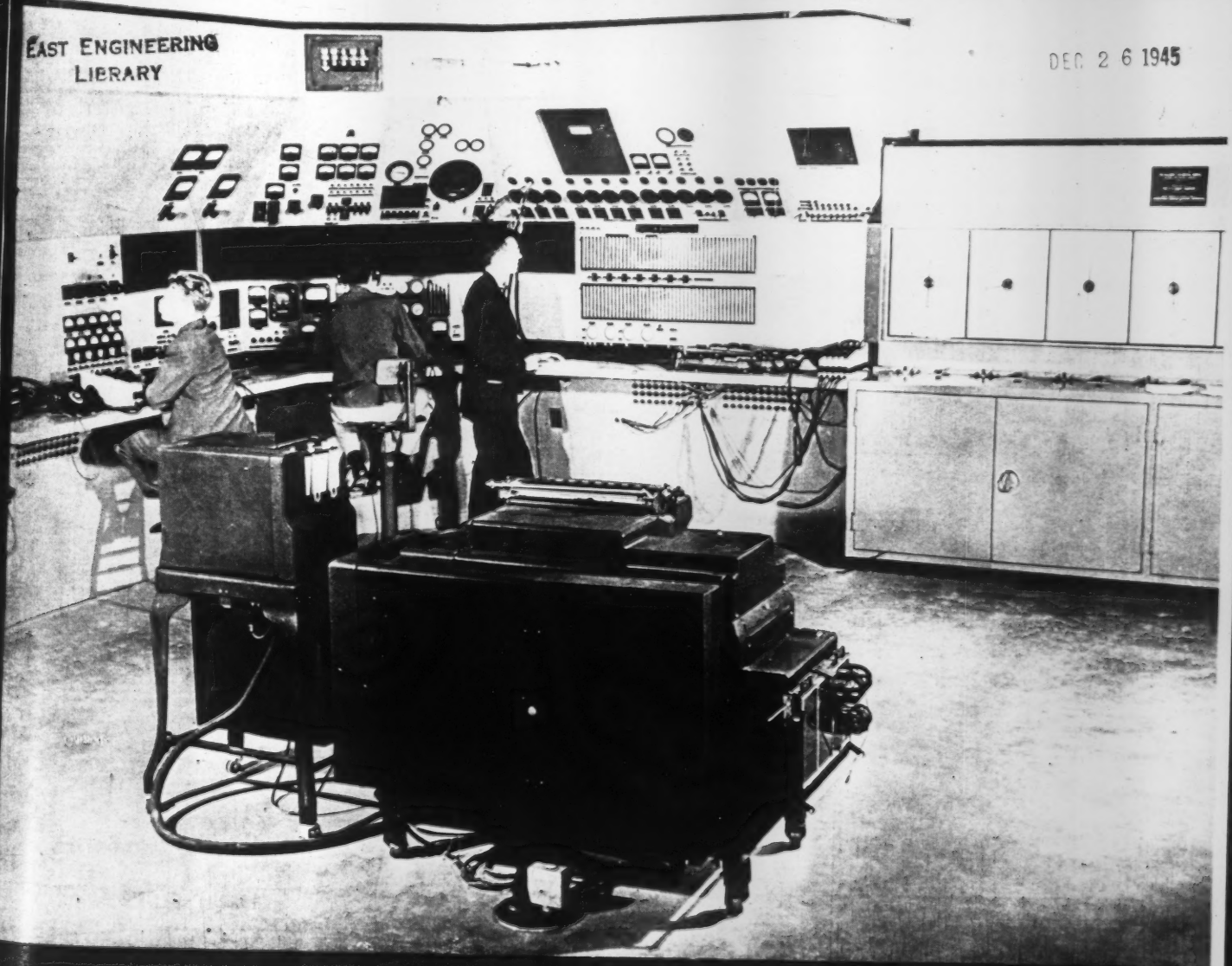

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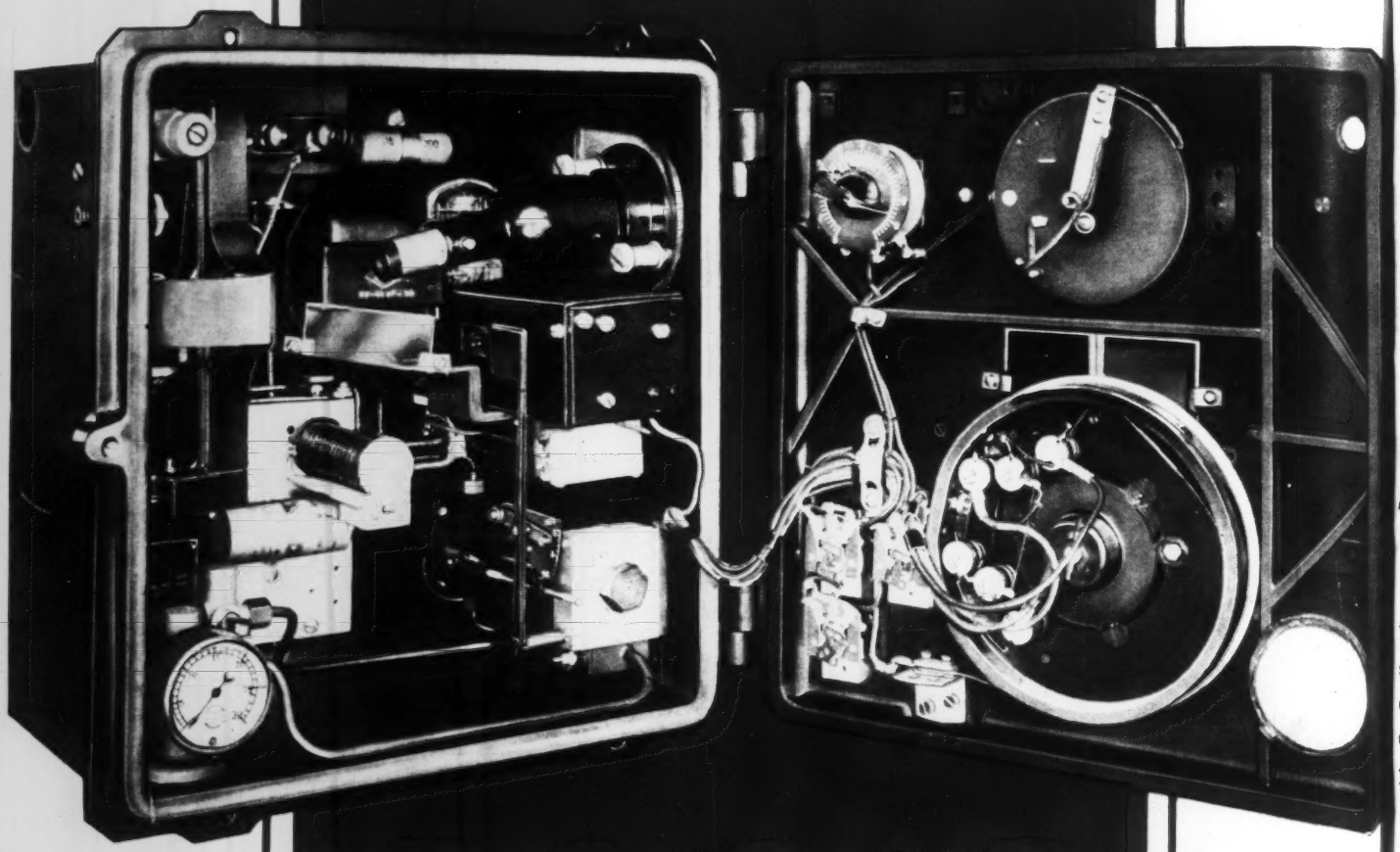

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$$\sigma = \frac{Mc}{I}$$

means improved design for high-speed machinery

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1. The specimen is easily prepared (see illustration), contrasted with the former complicated, highly-machined specimens required by other types of fatigue equipment.
2. An electronic control circuit maintains constant amplitude.

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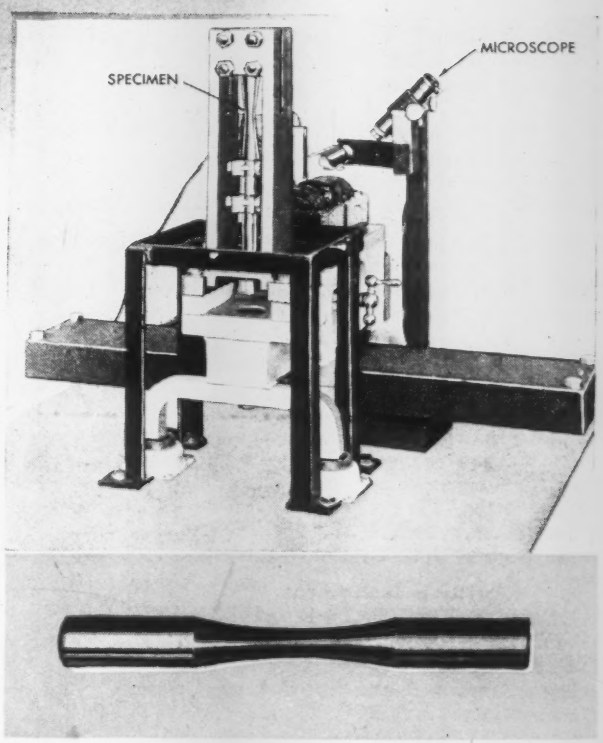
Your nearest Westinghouse office can give you all the facts on this timesaving, accurate achievement in high-temperature fatigue testing: Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-08134



High-temperature fatigue equipment, shows motor and specimen assembly with furnace removed. Inset shows easily-prepared specimen ready for test.

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Electronics at Work

Instruments
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(Courtesy Westinghouse Elec. Corp.)

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RICHARD RIMBACH, *MANAGING EDITOR*
M. F. Béhar, *Editor*
Paul Conrad, *Associate Editor*
Malcolm Lovejoy, *Assistant Editor*

DISTRICT OFFICES AND MANAGERS

Boston 14: James Condon, 36 Myrtle St., Telephone Lafayette 0829
Cleveland 14: C. Goldcamp, 859 Leader Bldg., Cherry 2261
New York 17: R. K. Farnham, Room 615, 17 East 42nd St., Telephone Murray Hill 2-0821.
Chicago 1: Harold W. Haskett, Room 615, 360 N. Michigan Ave., Telephone Andover 4299
Cincinnati 2: Harold W. Haskett, Keith Bldg., Telephone Main 4260
St. Louis 1: James R. Wright, 915 Olive St., Telephone Chestnut 1965
Pasadena 1: M. D. Pugh, 35 S. Raymond Ave., Telephone Madison 6272
Pittsburgh 12: C. Goldcamp, 1117 Wolfendale St., Telephone Fairfax 0161
Philadelphia: Stuart Rogers, contact at New York office

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

TWENTY years ago, ridicule met the prediction that Instrumentation would be recognized not only as a distinct science and a distinct technology but as a distinct occupational field on all levels: professional, trade, etc. Now that Instrument Men are organized or being organized on various levels, it is in order for your editor to "cover" meetings of the old-established scientific and technical societies to which he belongs. Some day, Instrument Societies, too, . . .

FROM Monday morning November 25th to late in the evening of Thursday the 29th, the 66th Annual Meeting of the American Society of Mechanical Engineers went on in numerous rooms on several floors of the Pennsylvania Hotel in New York—but even this huge hotel could not provide all the space needed: the principal banquet had to be held at the Hotel Astor; numerous committee luncheons and dinners were held at the Engineers' Club and numerous committee meetings were held in the Engineering Societies Building, in the Engineers' Club and elsewhere.

Not only space but time was short, so that the first meetings of various committees were held Sunday morning the 24th and the last ones were to be continued until Sunday, December 2nd—but *these* were not on the program!

Three of the ASME's eighteen Divisions celebrated their Twenty-fifth Anniversary: the Aviation Division, the Materials Handling Division and the Wood Industries Division. Therefore the program emphasized these three fields of research and of practical applications. But *Instruments* readers will be interested to learn: (1) that the ASME's two-year-old Instruments and Regulators Division* sponsored presentations of papers at no fewer than five sessions; (2) that papers describing new instruments or new instrument uses were included in eleven other sessions; (3) that instrument subjects were prominent — as usual — in the simultaneous sessions of the Society for Experimental Stress Analysis** at the Hotel Astor; and (4) that the Power Division's session on Thursday evening was a "Marine Symposium" entirely devoted to Automatic Control of Marine Power Equipment.

The printed Program, as usual, was a 5" × 8¼" paper-bound book. This year it had 84 pages! The Speakers' Index occupies five pages and lists no fewer than 240 names!

Passing now from the statistical to the mental, spiritual, political, ethical, juridical and other immaterial aspects, it is worth mentioning that absolute freedom of expression (within decorum) prevailed at all technical sessions—especially at sessions dealing with management and labor, etc. Similarly, some of the speeches at the discussionless luncheons, dinners, etc., presented opposite viewpoints on controversial topics. To be sure, no program committee invited advocates of Communism or Fascism, but there was a healthy airing of the different philosophies of Americanism —especially when the future of our beloved nation was discussed—and several men of prominence in public life did not mince their words. We could fill ten pages with extracts from such speeches. One fair sample will do in conclusion. It is from the speech of Dr. L. A. Hawkins of G.E.:

"I can see no hope of averting the most horrible of all wars except by the establishment of a strong international organization to outlaw atomic bombs and enforce their outlawry. . . .

"Physical science stands today where Europe stood when Columbus announced the discovery of a great new world, of unknown dimensions and unknown riches, calling for vigorous exploration and development."

Dr. Hawkins said he favored the Magnusson bill over the Kilgore bill. Of the May-Johnson bill he said that "in its original form it was a monstrosity, setting up a Commission with unprecedented arbitrary powers, superior alike to the law of contracts and Congressional control, placing American nuclear research in a strait-jacket, while leaving foreign scientists free, and providing savage penalties savoring of the Gestapo for violation of the least of its regulations.

"All early official utterances and official actions, such as the passage by the House of the original May-Johnson bill, emphasized an intent to maintain secrecy as completely and as long as possible. The distrust of our Allies and lack of confidence in the future of U.N.O. which we thus showed could evoke only distrust and fear in other nations and poison the international atmosphere.

"It was glorious news that emerged from the Truman-Attlee-King conference, that we have turned away from the isolationist policy of rigid secrecy, which would surely have led to the most direful armament race in history, and have agreed to use our temporary advantage to promote the consolidation of a strong international organization, through which alone can we hope to find effective outlawry of the atomic bomb and peaceful security for the world.

"If we resolutely turn our backs on defeatism and face our problems with courage and with open minds, we can glimpse beyond them an inspiring vista of a great new world."

To which we can say Amen! —MFB

*See January 1944 *Instruments* which was a Special Issue in its honor. 65 Division Members were listed in that issue; now there are 650. Cause and effect?

**The SESA and the ASME are of course separate bodies, but harmoniously coöperating as to dates, places and subjects, since many members of the ASME's Applied Mechanics Division (and of other Divisions) belong also to the SESA.

Paper limitations having been removed, *Instruments* is carrying out plans to serve the reader better, to bring the reader more information in more usable form. Important new editorial services will be added as soon as details can be worked out; the editorial staff has already been enlarged. Beginning in January, the paper used for printing will be 30% heavier than the war-years paper and the pre-war 8⅝" × 11¾" size will be resumed. Finally, the end of paper rationing enables us again to accept subscriptions, both domestic and foreign. For rates see page A4. —Richard Rimbach, *Publisher*

The Counter Reads 00216

and thereby registers the end of the eighteenth year of *Instruments'* service to users of measurement and control devices—service to the UNITED STATES OF AMERICA

The entire staff of *Instruments* wishes you

A Merry Christmas and a Happy New Year

Combustion Protective Controls*

By D. A. CAMPBELL, Manager Industrial Division, The Bryant Heater Co., Cleveland, Ohio

WHEN Mr. Roberts wrote me that the Program Committee was desirous of having this talk, he indicated as a subject "Safety Controls." I suggested that the subject be changed to "Combustion Protective Controls" as it has always seemed to me that the term "safety control" was misleading and sometimes caused considerable difficulty by building up in the mind of users the idea that protective control units, or measures taken for protection, would of themselves give complete safety regardless of any further action on the part of the operator or user. As this is far from true, I have always felt that such controls should be called "protective controls" in order to build up in the mind of the purchaser and user the idea that the devices were merely additional tools to assist him in securing complete protection for himself and for the equipment he was operating. All of you have undoubtedly seen installations in which well-designed and fundamentally correct equipment has been improperly installed or has been used in connection with the wrong auxiliaries, with the result that the very item which was supposed to produce safety introduced a hazard.

In order to discuss combustion protective devices, it might be desirable to review briefly the need for such devices and to show why changes over the last 15 to 25 years have produced such devices and made their application almost imperative. In this talk I should like to confine myself to protective equipment as applied to combustion practices and only in connection with the combustion of the commonly-used fuels, such as coal, oil, gas, and combinations of these.

When burning coal on an open grate with natural draft and a straight flue travel, there is scarcely any way in which an explosion can be caused. This is true whether you are firing manually or with automatic stoker equipment. Should the stoker equipment stop, the fire will simply burn out in place. It may damage the grate equipment in doing so, but would hardly constitute an explosion or combustion hazard.

However, when the process of coal combustion is improved by finely powdering the coal and blowing it into a combustion chamber in a stream of air, it is easily possible for the mixture to be such that combustion is fast and complete if there is a flame present; but if ignition is delayed until an unburned accumulation occurs, an explosion might result. Inasmuch as the process of pulverizing the coal and carrying the finely divided coal into the combustion chamber is more complicated than simple grate firing, it immediately introduces a requirement for automatic machinery, and the desirability of protecting against the hazard of delayed ignition becomes more and more imperative.

> A protective device should at all times prevent the introduction of combustibles into a furnace or appliance *unless* suitable means are present for immediate and continuous ignition of the combustibles. If such ignition does not take place, or does not proceed properly, the protective device should *at once shut off the fuel and then either re-establish the ignition system and, if safe after purging, again start the fuel going into the furnace, or should warn the operator, who can restart manually.* The operation of such a device should, of course, depend *only* on the presence or absence of flame and should be independent of ambient temperature conditions.

Considering the combustion of oil, somewhat the same process has taken place. The simpler type of oil burners consisted of nothing but jets which more or less satisfactorily broke up the oil stream into a spray to permit mixing with air for combustion. The air was usually supplied by natural draft and usually in considerable excess so that it was not only difficult to secure even a combustible mixture, but it was also almost impossible to secure an explosive mixture. In the attempts to improve efficiency, various devices were developed for more finely dividing the oil spray, or practically gasifying it and more thoroughly mixing it with air. These devices resulted in producing mixtures that were capable of almost instantaneous combustion. The introduction of such mixtures in the combustion chambers led to the necessity of continuous ignition because if ignition was delayed until the combustion chamber filled with such a mixture the resultant explosion was usually quite serious. A good operator could, of course, always place such a unit in operation and keep it in operation by using reasonable care, but when it was desired to do this automatically, it became more and more difficult to protect against the hazard introduced by use of such a mixture.

In the combustion of gas, either natural or manufactured, or by-product gas of various types, the hazards are much more apparent because these fuels are immediately ready for ignition if the right amount of air is mixed with them, and by their very nature they tend to mix immediately if introduced in the same chamber with air; whereas, of course, unvaporized oil might merely fall to the bottom of the chamber without mixing with air, and unpulverized coal could simply lie on the combustion grates. Again it should be noted that in the early uses of gas, particularly natural gas, no great attention was paid to efficiency or improvements in firing, with the result that open burners, placed through holes in the walls of large brick lined combustion chambers, were used and the operator was given considerable latitude to maintain combustion regardless of efficiency involved. However, as time went on it became desirable to exactly control temperature in various industrial processes and to improve combustion efficiencies because of rising cost of gas. So better and better combustion equipment was developed, including completely enclosed burners and mixing equipment to supply exact combustible mixtures at all rates of firing. Automatic ignition devices and starting devices were added to make the entire process fully automatic.

Particularly in the oven and low-temperature furnace field the requirement for protective equipment was made a part of the original specifications of new equipment going into operation. This was probably because many of these ovens and low-temperature furnaces were installed in plants in which a great many workmen and workwomen, who had no knowledge whatever of combustion practice, were required to work in close proximity to these ovens and to operate them. It therefore became desirable to equip these ovens so that they would be fully automatic and could be operated by the least experienced operator with a minimum of training. The insurance com-

*Presented before the New Jersey Society for Measurement and Control, Newark, N. J.

anies gan to study the question of azard hus introduced and to urge the se of rotective equipment to reduce e nu er and size of the explosions hich gan to be rather frequent in is ty of equipment. Their labora- ries k up the question of develop- g pr ctive equipment where equip- ent s not already available. Un- rwrit s Laboratories, Inc., and the borat ies of the Associated Mutual surar e Companies and the Factory surar e Association, as well as the gineer ng departments of some large surar e companies, have gradually olved odes covering specifications of rotecti e equipment for many types ovens and furnaces and have tested nd app oved or disapproved numerous ems of ered for sale by various com- anies manufacturing such equipment. hese insurance companies have been strumental also in a great deal of ducation of users and have helped reatly in the acceptance by industry various types of protective units.

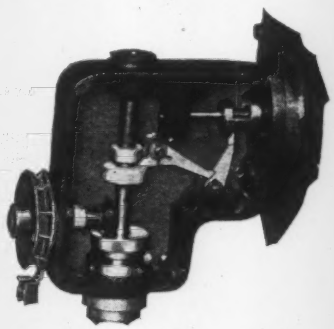
It can readily be seen, in reviewing e foregoing, that as combustion fficiencies improve and factory prac- ces demand automatic ignition and ntrol equipment, the necessity for rotection against the hazards due to ilure of any of this automatic equip- ent becomes more and more impera- ive.

I should like to read a few lines from n excellent paper on "Protective quipment" given by T. A. Cohen, Vice resident of Wheelco Instruments Com- any several years ago:

"The records of a single under- writing organization, conspicuously active in the application of safety equipment, show that within the period of 10 years—from 1928 to 1937—in boiler furnaces there have been 44 oil-fired explosions, 13 gas- fired explosions and 12 pulverized- coal explosions.

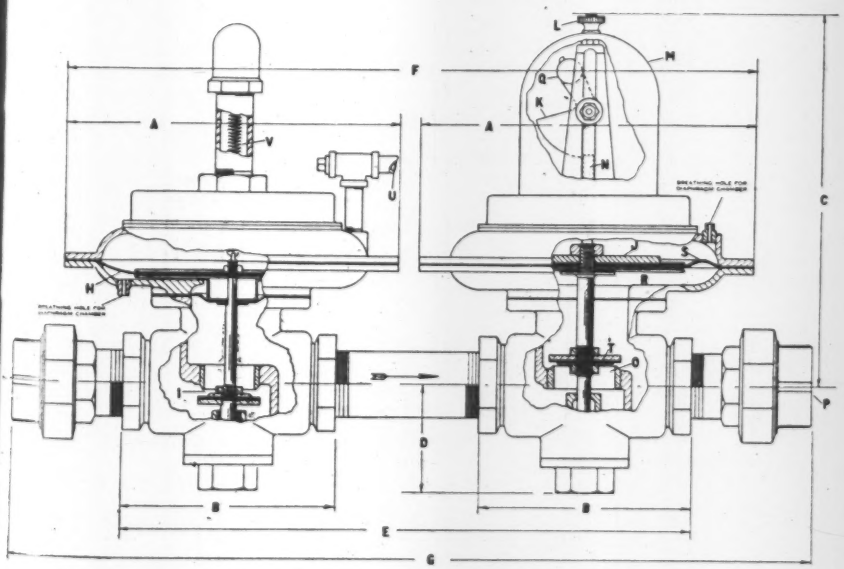
"It is significant to note that al- though there were 44 explosions with oil-fired equipment, as against 13 for gas, and therefore a greater outlay in loss payments—it does not neces- sarily mean that oil fuels are more hazardous than any of the other fuels, since a great deal of this may be accounted for by the more wide- spread use of oil-fired equipment."

At this point it might be desirable to discuss briefly what a protective de- vice should do in connection with in- dustrial fuel combustion. In considering the combustion of any of the fuels which are actually ready for immediate combustion, such as gas, highly-vap- orized oil, or powdered coal, there are two distinct hazards; one during the starting-up period and the second dur- ing the operating period. Both of these hazards are much greater if the com- bustion chamber is maintained below

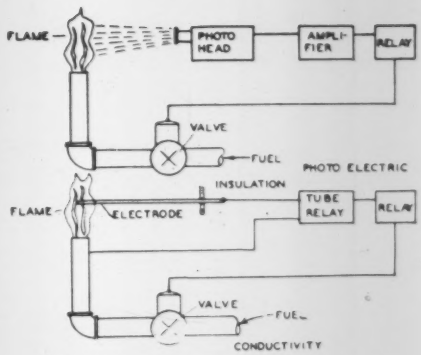


Indirect pressure-acting gas shut-off valve manually reset after failure; shown with triggers in cocked position, valve open. *(North American Mfg. Co.)*

normal ignition point of the fuel, either by nature of the process involved or the use of water walls or other method of absorbing heat rapidly enough to keep the combustion chamber below the igni- tion point. If all portions of the combus- tion chamber are at a very high tem-



Cross section of direct-acting pressure-operated gas shut-off valve which can only be opened manually when both gas and air are above minimum pressure. *(Eclipse Fuel Engineering Co.)*



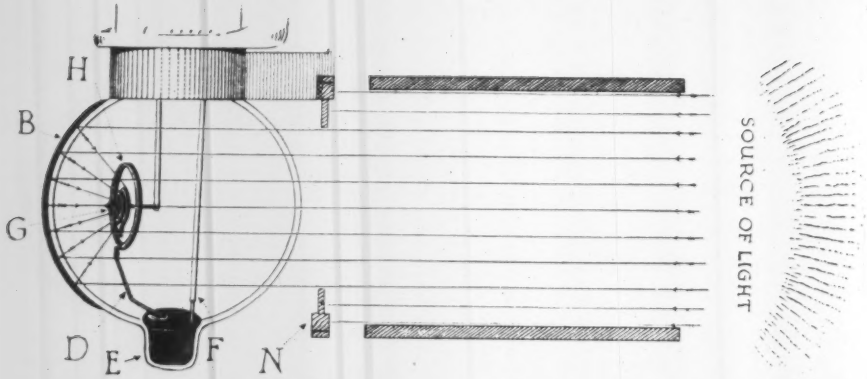
Showing comparison of simplified circuits using electrode and phototube arrangements. *(Wheelco Instrument Co.)*

perature (2000° F. or above) the ignition of any quantity of a complete fuel mixture is almost instantaneous and it is impossible to secure an accumula- tion of mixture which might cause an explosion. However, if the combustion chamber is below the ignition point, the chamber might easily become filled with combustible mixture which should then be ignited by any one of a number of means, such as external flame, an in- correctly-located pilot flame, a soot de- posit which is still above ignition tem- perature, or any sort of an electric spark. There have been cases where this spark has been produced by the opera- tor himself or automatic equipment tak- ing his place, but due to the delay in producing it, instead of merely quietly and smoothly igniting the mixture as it issued from the burner, it was exploded after accumulating in the combustion chamber.

A protective device should, therefore, at all times prevent the introduction of combustibles into a furnace or appli- ance *unless* suitable means are present for immediate and continuous ignition of the combustibles. If such ignition does not take place, or does not proceed properly, the protective device should *at once shut off the fuel and then either re-establish the ignition system and, if safe after purging, again start the fuel going into the furnace, or should warn the operator, who can restart manually.* The operation of such a device should, of course, depend *only* on the presence or absence of flame and should be in- dependent of ambient temperature con- ditions.

Development of Protective Equipment

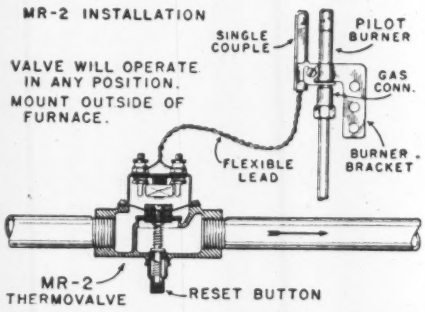
In tracing the development of protec- tive equipment we find that even before automatic control equipment became prevalent there were a number of de- vices developed which mechanically shut off the fuel should any failure of the operating equipment occur which might lead to a hazardous condition. For example, where oil and air are sup- plied under pressure for combustion, or gas and air are so supplied, there are a number of satisfactory units which will immediately shut off the fuel, either gas



"Type L Visaflame." This device resembles a radiation pyrometer which concentrates radiant energy—infrared as well as visible—on a tiny bimetal coil, but the bulb is made of glass which, though transparent to visible light, is practically opaque to infrared radiations, or "dark heat." This property of the glass assures actuation by luminous flame and not by the heat of a dark furnace: the flame light concentrated on coil *G* heats it above ambient temperature and causes it to uncoil, carrying movable electrode *D* into mercury pool *E*. The circuit is then closed between fixed electrode *F* and movable electrode *D*. *(Mercoid Corporation.)*

or oil, should the *pressure* of the fuel drop below a predetermined point, or should the air pressure drop below the safe point and keep the fuel off until manually reset. This means that one of the conditions which might develop a serious hazard is removed. This is because, in general, if ignition is once satisfactorily established in a combustion system, the mixture will continue to burn if the fuel and air supply are constantly available, but of course would stop if either one of them failed. A definite hazard would be introduced if, after such fuel or air failure and the consequent failure of flame, the mixture supply should be re-established, fill the combustion chamber and then be touched off.

Another series of fuel shut-off devices utilized weighted valves with a latch to hold the valve in the open position. This latch is combined with a magnetic coil in such a way that the latch will only hold the valve open as long as the coil is energized. By putting this coil in series with a pressure



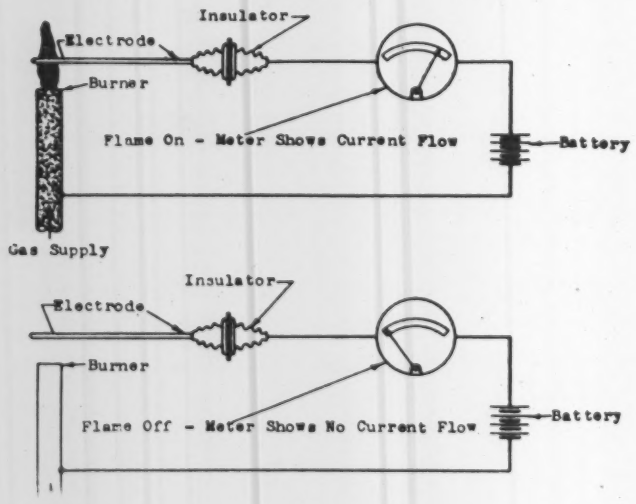
Thermocouple shut-off unit. *(General Controls Co.)*

switch in both the fuel and air line and taking its electrical supply from the same source supplying blowers or fuel pumps, a considerable measure or protection against low pressure of either fuel or air supply, or electric failure, is achieved. All of the devices that are approved by insurance laboratories require manual resetting.

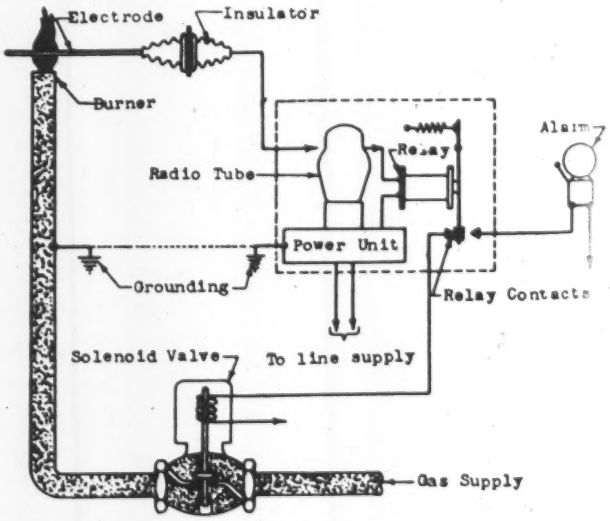
One of the early attempts to produce flame failure protective equipment used the thermal expansion principle in which a heat-sensitive device was arranged in connection with the combustion system so that it was necessary to continually maintain a flame impinging on this device to keep a valve open. The obvious difficulty with such a device was that it was not only sensitive to flame playing directly upon it but also to any heat, such as radiated from combustion walls, and if subjected to temperature beyond its normal capacity, such a device might take a permanent set, which, of course, was exceedingly dangerous, as it then kept the valve open all the time. However, many of these units are in use on open types of atmospheric burners on relatively small devices, where they are generally satisfactory.

Another early attempt in this direction was the utilization of thermocouples in place of the expansion thermal units. The electomotive force developed by these thermocouples when contacted by the pilot flame or main flame was used to hold a valve open. It as much as the emf. was very small and was dependent upon the temperature differential between the thermocouple and its cold junction, this device required the operator to manually start the pilot flame, or main flame, using a by-pass, and hold the valve open until sufficient electromotive force was developed in the thermocouple to continue to hold the valves. This unit has the great advantage that if the flame failed and the valve opened, it was not possible for a re-established flame of any sort, or any other heat source, to develop sufficient emf. to open the valve owing to the relatively large emf. required to open any solenoid valve. In other words, a manual operation was required to re-establish flame in case of flame failure. However, it was subject to lag due to extraneous heat.

During the past ten years a number of protective units were developed, including several electronic devices which



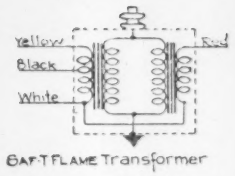
Drawings illustrating principle of current flow through flame. *(Wheelco Instruments Co.)*

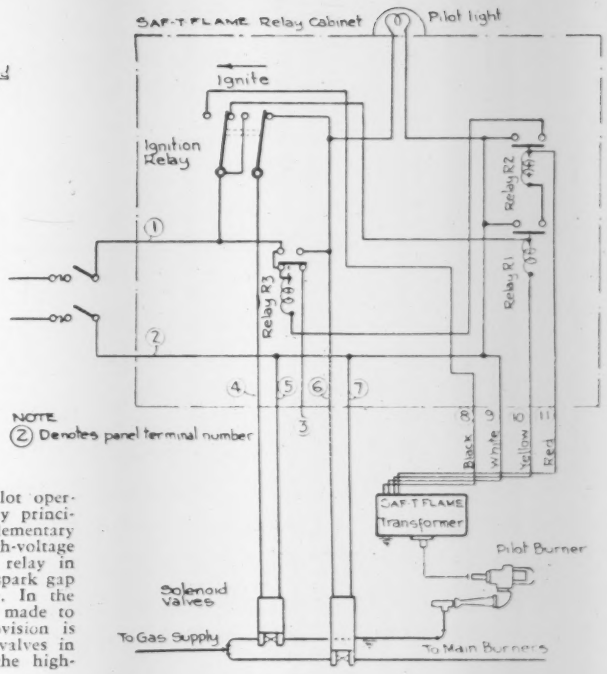


Application of current-carrying capacity of burner flame with electronic cut-off unit. *(Wheelco Instruments Co.)*

utili[z] the principle of flame conductivi[ty] of electric current. A small current through the flame was amplified and [by] its changes was used as a trig[ger] for operation of control relays. These devices required that the flame be well-grounded and that some sort of electrode or flame-contacting rod be in the flame to permit carrying the electric current through the flame. This is exceedingly difficult in the case of oil and powdered-coal firing, as such flames usually do not actually contact the burners or ground, but merely burn in suspension so that a suitable ground contact was hard to maintain. Furthermore, the combustion temperatures of these flames were so high that any type of metal flame-sensing rod which was suitable for conducting the actuating current would soon burn up and of course throw the system out of commission. For such applications a suitably installed photoelectric cell, which depends upon the light from the combustion flame, is used. In order to prevent this cell from responding to extraneous light and thus holding open the fuel valve even when no flame is present, means for filtering the light is introduced, either by use of colored filters or adjustable sighting openings.

There is also available a system which utilizes directly the flame conductivity as a switch for the main 60-cycle current at voltages of about 5000, rather than a small electronic current which must be electronically amplified. This eliminates the necessity for vacuum tubes but, as at present developed, this system is limited in its applications mainly to open flames. This non-electronic circuit in its simplest form consists of a high-voltage transformer with a sensitive relay in series with its primary winding and a spark gap in series with its secondary winding. The spark gap is so adjusted that no current can jump the gap unless a flame has been established in the gap. When such a flame has been established, current will be drawn from the supply through the winding of a sensitized relay to the transformer to ground and the relay will close. The relay contacts control the fuel valves and consequently when the flame is removed between the electrodes, no current can flow and the relay will drop out and the fuel valve will close.



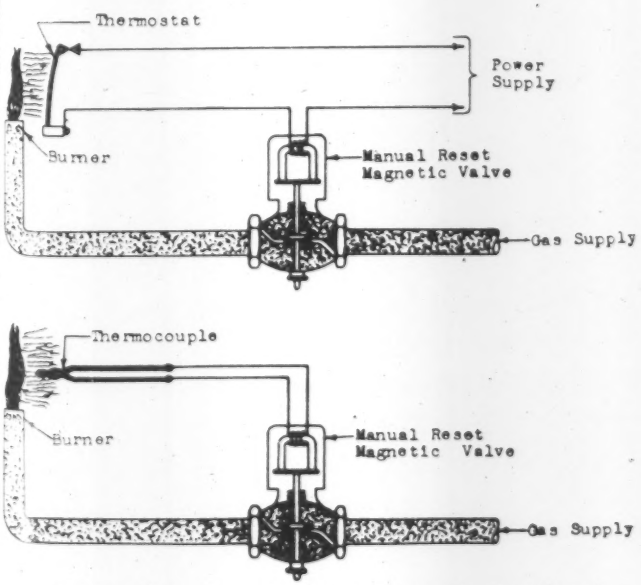


The "Saf-T-Flame" gas pilot operates on the flame conductivity principle. The circuit in its most elementary form would consist of a high-voltage transformer with a sensitive relay in series with its primary and a spark gap in series with the secondary. In the complete circuit provision is made to ignite the pilot burner. Provision is also made to close the fuel valves in case of a short circuit of the high-voltage circuit.

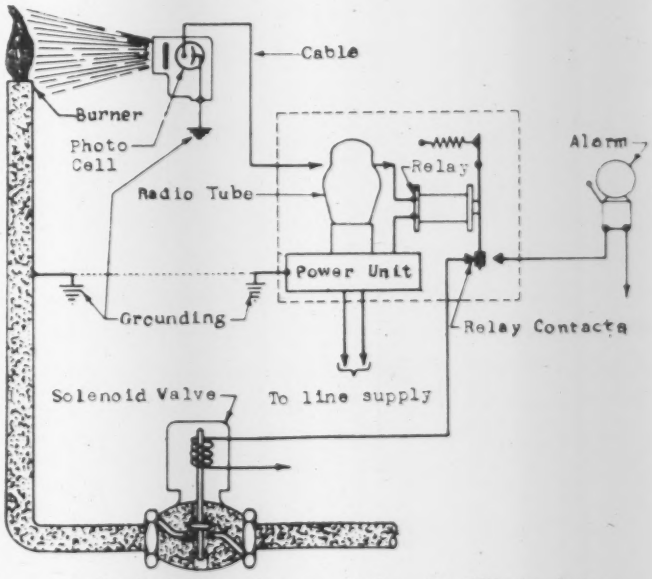
Sensitive relay *R*1 is in series with the transformer primary. Sensitive relay *R*2 is energized by an auxiliary transformer connected to the secondary of the main transformer. *R*3 is a line voltage relay controlling the fuel valves. When the ignition switch is moved to the left, supply current can flow directly to the pilot solenoid valve. Current flows also from the supply line through the ignition switch to a tap on the transformer primary (black lead), which energizes the transformer to produce a secondary voltage above normal. This voltage is sufficient to cause a spark to ignite the pilot. When the switch is released, it moves back to the right, allowing supply current to flow through the *R*1 relay coil to the primary voltage tap (yellow lead) of the transformer. Since the pilot has been lighted, normal high-voltage secondary current will pass through the flame and relay *R*1 will be pulled in, completing the circuit between *R*2 and secondary of auxiliary transformer (red lead). Closing of *R*2 completes the circuit to line-voltage-operated relay *R*3, the closing of which energizes both fuel valves. In the event of pilot failure, *R*1 will open, which in turn will release *R*2 and *R*3. In the event of a short circuit of the secondary circuit, the auxiliary transformer will be de-energized, which will release *R*2 and thereby *R*3. *(The Partlow Corp.)*

We understand that another type of electronic unit has lately been developed based upon the principle that a flame acts as a rectification device for alternating current. This arrangement eliminates the necessity for a-c. rectification and is somewhat simpler than the other devices mentioned above.

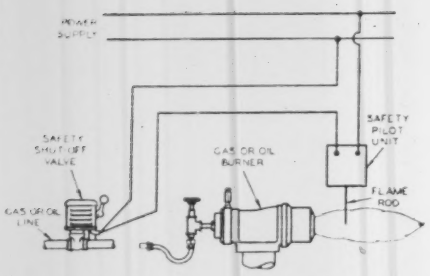
Examples of equipment utilizing the various processes mentioned above, as



Drawings illustrating principle of thermostatic shut-off and thermocouples shut-off. *(Wheelco Instrument Co.)*



Simple circuit illustrating use of photocell. *(Wheelco Instruments Co.)*



Safety shut-off valve, used with safety pilot to close supply line to gas or oil burner in case of flame failure. *(Maxon Premix Burner Co.)*

applied to gas and oil fuel, are as follows:

1. The mechanical pressure failure devices, such as manufactured by North American Manufacturing Company and Eclipse Fuel Engineering Company, in which weighted diaphragm valves must be manually latched open and will only stay open when the fuel and air are under proper pressure.

2. The electric latch valve fuel shut-off, such as made by Maxon Burner Company, General Controls Company, Western Products Company and others.

3. The thermal mechanical units, which are quite numerous, include various thermal expansion devices made up with either bimetal and unimetal elements, and the Visaflame manufactured by Mercoid Company.

4. Thermoelectric type, including units manufactured by Brown Instrument Company, Milwaukee Gas Specialty Company, and General Controls Company.

5. Electrical but not electronic units based on flame conductivity, such as manufactured by the Partlow Corporation.

6. Electronic units based on flame conductivity, such as Flame-O-Trol manufactured by Wheelco Instruments Company, and Protectoglo made by Brown Instrument Company.

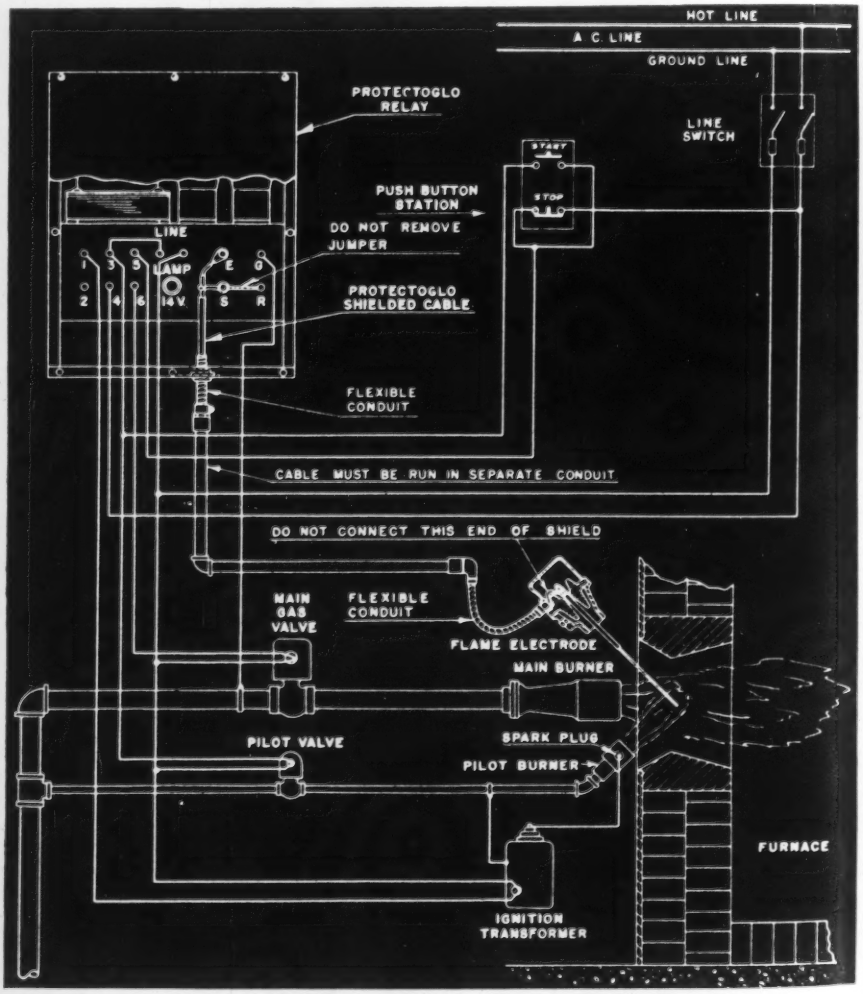
7. Electronic units based on flame rectification, as manufactured by Brown Instrument Company.

We understand that there is an electronic unit being developed which is based on the stroboscopic effect of flame vibration but not knowing any details about it, I cannot describe it for you.

In considering the type of equipment to be used on a particular installation, there are several factors which must be given proper weight. First, a decision should be made as to whether only shut-off protection in case of flame failure is desired, or whether automatic re-ignition is to be incorporated. Almost as important as the type of equipment is a knowledge of its limitations as applied to various combustion systems. For example, it would be ridiculous to install a thermal expansion type unit in a high-temperature closed combustion chamber. On the other hand, there is no particular advantage in using the electronic type in case of a simple open atmospheric burner with ample secondary-air conditions because the simpler and very much less expensive thermoelectric unit will probably meet all requirements fully.

In addition to the flame-sensing device, it is necessary to use the proper shut-off valves to give the type of closing desired, both from the viewpoint of speed and action and tightness of closing. There would not be much use in working out a complete shut-off arrangement if the valves that were specified permitted sufficient leakage under any condition to offset the advantage of complete flame failure shut-off. Here it is also advisable to point out that unless sufficient protective equipment is installed to really do the job, there is no advantage in putting in the system. In other words, partial protection might be, and in many cases is, much more dangerous than no protective equipment at all. The reason for this is that the equipment must either be able to function completely without the operator, or the operator must be trained not to depend on it, and if he can't depend on it there is not much use in putting it in. Many cases have occurred where only warning signals were installed and not fuel shut-off equipment. It is doubtful if these so-called warning systems ever re[pay] for themselves as usually wi[th the] warning is given the operator [to-] where to be found and when h[e] [es] show up, it is frequently too late. [a] fuel shut-off unit had been incorpo[ed] with the warning, a full measu[re of] protection would be afforded.

This brings up the point that u[ss] considerable pains are taken to [or-] oughly and completely sell the oper[ors] themselves on the advantages o[f the] protective equipment, and also t[o im-] press upon them thoroughly the li[mita-] tions of the equipment, not much [value] will be gained by its installation. [If the] operator feels that the protective [equip-] ment is merely another gadget [which] will slow down his production if it [shuts] down the fuel, he will work out ways to by-pass it and then when it is really needed it cannot operate. It is sometimes necessary, because of required continuity of operation, to install by-passes around protective equipment, but in such cases these by-passes, or shunts, should be arranged with keys so that no one except an authorized individual in authority can cut out the protective equipment. This cut-out should be full and complete so that when the shunt is made the operator



"Protectoglow" flame electrode system. Installation diagram showing standard application non-automatic relight. *(Brown Instrument Co.)*

fully understands he is operating on his own and without any protection whatever.

Assuming that the correct equipment has been selected and that the correct valve equipment is being used, it is also most important that the installation be made correctly. This sometimes involves relocation of pilot equipment and always involves proper location of flame sensing equipment, valves and push buttons, so that when the system is being used the operator's work is made easier rather than more difficult. In this connection I have in mind one installation on an oil-fired boiler which required three men to start it up because the various push buttons, lighting torches and hand-operated valves were so badly arranged that no one man could have handled them; in fact, two men could not handle them so it took three to do the job. A comparatively simple rearrangement of the equipment made it easy for one man to handle the entire operation and be protected throughout the starting operation.

It requires a good combination of proper selection, correct application and well-made installation to eliminate false shut-downs. By false shut-downs we mean shut-downs which occur for reasons outside of actual flame failure. Naturally, false shut-downs can be eliminated if the various requirements mentioned above are fully met.

You can readily see that the proper maintenance of protective equipment is exceedingly important. This is particularly true of the electric or electronic type because, like any electrical equipment, it may be subject to failure due to corrosion, stray currents, sticking contacts, or failure of the component parts. Although most of the protective equipment is designed so that failure of any component part will shut down the unit and thus promote safety, such failures might cause false shut-downs and be exceedingly expensive from the operating point of view. Regular and frequent inspection and check will bring to light any cause for false shut-down which can immediately be remedied. It is well at the time of installation to provide means for making such checks during operation. Such means are the key type shunts or bypasses mentioned above.

All of the foregoing has been quite general, but now we will attempt to be specific as to some of the Do's and Don'ts in regard to application and installation.

1. Don't attempt to install a pilot and protective unit requiring secondary air in a combustion chamber where no secondary air is available or where the chamber is under more than atmospheric pressure.

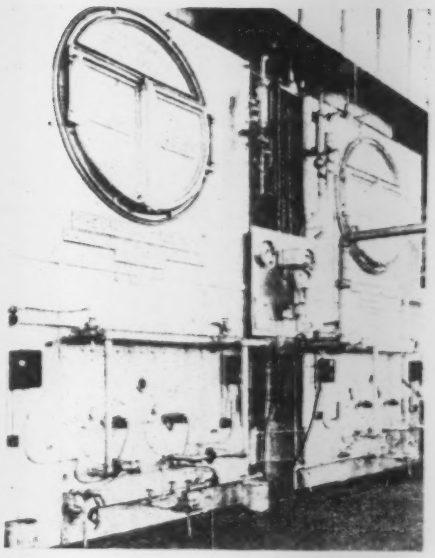
2. Don't attempt to use a thermal expansion or thermoelectric type unit where immediate shut-off is desirable because the lag introduced by ambient temperature may slow such an operation down to as long as five minutes, during which time considerable fuel can accumulate in the chamber.

3. Keep in mind that electric equipment will not operate properly if subjected to serious moisture conditions. This is particularly true of electronic equipment, such as used in flame failure equipment, where even a slight moisture film may cause the equipment to operate unsafely by causing current leakage which imitates flame conditions.

4. Don't assume that you know more about the installation than the manufacturer of the equipment and attempt to shortcut his installation requirements. Each item of his requirements has been carefully developed to meet a definite hazard and you cannot expect correct operation unless you install the equipment according to his directions.

5. Particularly in the case of electrical equipment, it is necessary that proper voltage be applied, as undervoltage may prevent valves from opening when they should and over-voltage may cause them to remain open when they should close.

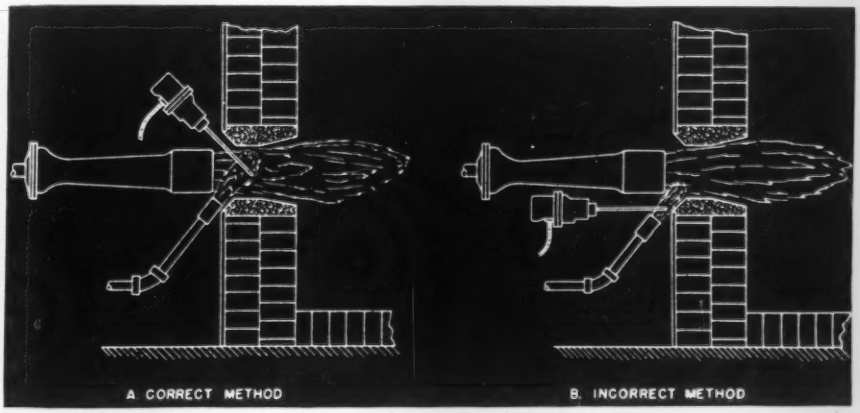
6. No system will operate safely without satisfactory accessory equipment, so be sure that such parts of the installation as solenoid valves, relays, pilots and wiring are not only the best procurable but kept in good condition.



Front of gas-fired boiler protected by automatic flame failure shut-off equipment; non-automatic relight. *(Wheelco Instruments Co.)*

7. In case of difficulty in operation don't condemn the equipment until you have really eliminated all the possible sources of trouble outside of the equipment. After a good many years of experience using electronic protective equipment on gas-fired units, I can truthfully say that the number of cases in which the equipment itself was actually at fault were so few I could count them on the fingers of one hand.

8. No flame-failure protective device yet developed will do more than check one flame at any particular moment. This means that multiple burners which will not immediately light from one to the other require a separate unit for each burner. There have been developed systems with rotating switches using a number of sensing electrodes with one flame-failure relay. These tend to be complicated and difficult to maintain, but are being improved continually.



Illustrating correct and incorrect method of sensing rod installation in flames. *(Brown Instrument Co.)*

In conclusion:

1. Combustion protective equipment is desirable.

2. As combustion practices become more automatic, protection is necessary as well as desirable.

3. Insufficient protection may be more dangerous than none.

4. Installation and maintenance are as important as proper selection and good design.

5. Most new combustion equipment being developed will incorporate correctly-engineered protective devices or arrangements.

In closing I want to express my appreciation of the help given me by various manufacturers of protective control equipment who loaned slides and contributed data. These include Partlow Corporation, Brown Instrument Company and Wheelco Instruments Company.

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

FOREWORD

IN this age of science, nearly everything we use and do has been improved by research. We are well aware of our debt to the men who have so raised our standard of living, but few of us realize that their research is absolutely dependent on the men who work glass.

Without glass, the development of our technologic culture would certainly have taken a very different course. Its unique, well-known chemical and physical properties make it a necessity in nearly all lines of experimentation.

The history of scientific glassware has passed through three rather definite stages. From the beginning of science to the end of the last century, only the simplest glass apparatus was known; flasks and retorts and tubes were used, and they changed very little in form through the ages. Then more complicated unit apparatus was introduced, such as all-glass condensers, multiple-necked flasks, and elaborate automatic extraction devices. These were standardized and manufactured for specialized uses, and they were rarely altered. Finally, the last quarter century has been marked by the development of custom-made glassware. Through close coöperation between the workers in glass and in research, large and complicated apparatus, especially designed for the problem at hand, can be built quickly and easily. Rubber hose connections have given way to all-glass construction, to great advantage, and now it is usual to see a laboratory almost filled with one vine-like piece of glass.

The purpose of this book is to aid the experimentalist in using glass; it should do so in two ways. First it should teach him, with moderate practice, to perform the simple operations himself. Skill in making small seals is now required in many types of laboratory work, because such construction is required very frequently in connection with assembly, alteration, and repair of apparatus, and a professional glass blower is rarely available on short notice. In so doing, the experimentalist in no way competes with the expert glass worker, but relieves him for difficult work. Very few scientific workers become highly skilled in working glass, and it is not necessary that they do, but some knowledge of the art is becoming more and more important.

This book will also help the laboratory worker design complex equipment more intelligently. The services of an expert glass blower are of little use unless they are understood by the man who designs and uses the equipment. The more advanced portions of this book are intended to explain what the professional can do, rather than the details of how he does it, which can only be learned by long practice.

In brief, this book tells about the glass blower's fires which are older than Aladdin's Lamp, and have already wrought greater miracles.

JOHN R. BOWMAN

Mellon Institute of Industrial Research

SCIENTIFIC GLASS BLOWING AND LABORATORY TECHNIQUES

IN the last decade the task of making glass equipment for use in a modern research laboratory has become increasingly important. The perfection of certain types of glasses has augmented a general demand for glassware because of the sturdy equipment that could be made to withstand general usage in the laboratory. The scientist, especially the chemist, has become dependent upon glass as one of the chief materials for the fabrication of containers in which his studies are made. The advantage of observing the action of various chemical reagents under various temperature and pressure conditions has been invaluable to the research chemist. In general he has also found that some glasses are relatively inert toward chemical reagents and equipment made of these glasses could be used many times. Because the scientist has come to rely on glass equipment, the art of making specialized scientific glassware has become a distinct department in the profession commonly called *glass blowing*.

The term "glass blower" has a broad meaning and usually brings to mind the person who at various demonstrations makes artistic articles with the dexterity that often seems uncanny to the layman. Manual production of glass articles by the use of large blowpipes is also called glass blowing. A comparatively small group of persons, however, have developed the techniques of making equipment for research laboratories and it is to this group that the research chemist is greatly indebted.

Many research laboratories do not have a sufficient number of glass blowers and to carry on their work, numerous scientists have found it necessary to do a great deal of the simpler glass operations themselves. The skills they acquire are usually obtained by courses in glass blowing or by individual practice. It is for this group that the basic principles which are later outlined will be helpful in learning to do a good job of glass blowing.

The glass blower who makes the equipment for the present-day scientist is one who has spent many hours in developing the skills and techniques necessary for this kind of work. His job is more difficult than the various special crafts of forming and making equipment from metals or plastics because a great deal of his work must be completed by hand-working the glass. He has found the burner used in heating the glass as the most dependent tool. The adjustment of this burner to give flame temperatures representative of the gas that is used as fuel is one of the basic techniques to be learned.

The choice of the gases which are to be used in the burner is dependent on the type of glass to be worked. Natural gas when used with air will permit the working of lime glass or what is commonly known as a type of soft glass. The addition of a small amount of hydrogen to the air gives a slightly higher flame temperature. The substitution of oxygen instead of air gives a flame temperature which is ordinarily used in working Pyrex (the Corning Glass Works trade name of one of the most commonly used glasses in the research laboratory). Hydrogen and oxygen, when used in the ratio of two volumes of the former and one part of the latter, give a very hot flame conveniently used in working vitreous silica or glasses with a very high

TABLE 1. Commercial Fuel Gases

Gas	B.T.U. per Cubic Foot	Volume Percent H_2	CO	Methane Plus Ethane	Propane and Butanes
Coal Gas	527	58	6	27	0
Natural Gas	1100	0	0.1	89	2
Bottled Gas	3037	0	0	0	100

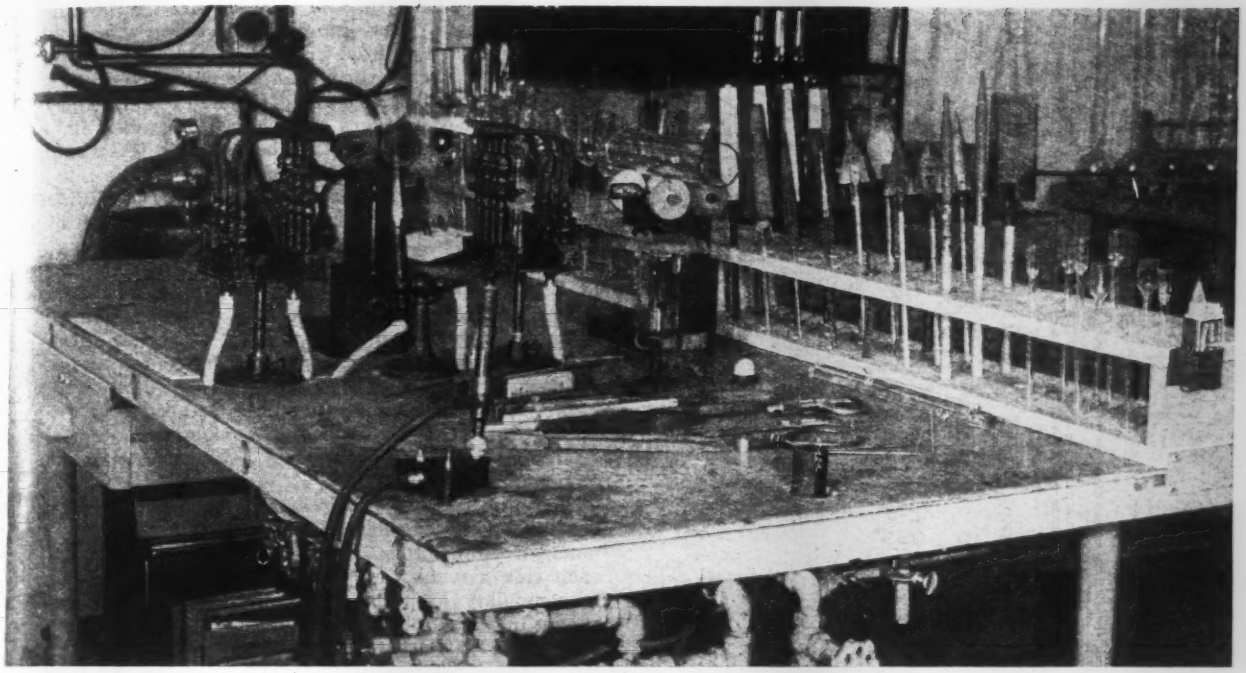


Fig. 2. Table top arrangement, showing location of valves, burners and tools.

silicon content. Oxygen and acetylene are also used in working these types of glasses. The average heating values and compositions of some commercial fuels are given in Table 1.

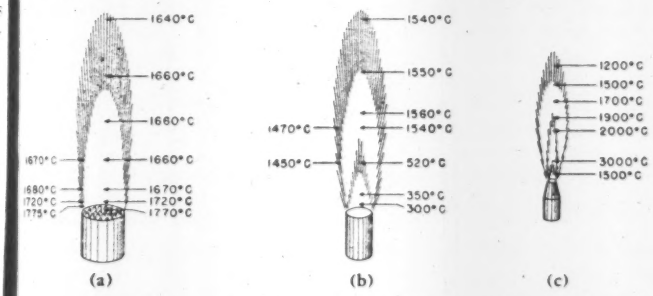


Fig. 1. The temperature distribution in the flames of (a) Meker, (b) Bunsen, and (c) the acetylene torch. After F. Haber.

The temperature distribution in the flames of blast burners is usually dependent upon the rate of combustion and the gases used. The temperature distribution in the flames of the Meker and Bunsen burners in which gas is used with air is given in Fig. 1a and 1b, while that of an acetylene torch is given in Fig. 1c.

The Glass Shop

The plan for the glass shop should be carefully considered. The work table is most conveniently placed so that the glass blower has sufficient room on at least two sides for freedom of movement when long sections of tubing are handled. A surrounding free space of at least four feet is adequate. Since the table is to serve as a work bench, all utilities such as gas, oxygen, vacuum and air are located under the edge of the table within easy reach of the worker and preferably close to the location of the various burners. The respective manifolds should be fitted with needle valves for precise control.

A table of about 6 to 8 ft. in length and 3 ft. in width is satisfactory. A height of 38" is suitable for the average person. Transite about ⅜" thick will protect the table top from heat and hot glass. Special burners as cross fires will require slots in the table top for adjustment. A wooden rack with holes of different sizes is convenient as a holder for glass, tools and stems. A suitable table-top arrangement is shown in Fig. 2. The table shown here is supported by 2" standard pipe joined with crosses and tees.

Burners

Blast Burners: The burner of the Massachusetts Institute of Technology type, Fig. 3, is first in the order of importance in discussing glass blowing fires. This single jet blast burner is connected to the gas and oxygen or air lines by rubber tubing of sufficient length to allow movement of the burner to any position of the working space on the table. Three interchangeable jets provide a wide range in flame size. The burner is best adapted for small work and all side arm seals.

Air is used with gas in this burner for all soft glass work. However, an oxygen and gas mixture is suitable for soft glass work if a small quiet flame is used. When laboratory resistant glass such as Pyrex is being worked, an oxygen and gas mixture must be used. The oxygen jet should extend ⅛" beyond the outer shell for a minimum flame width.

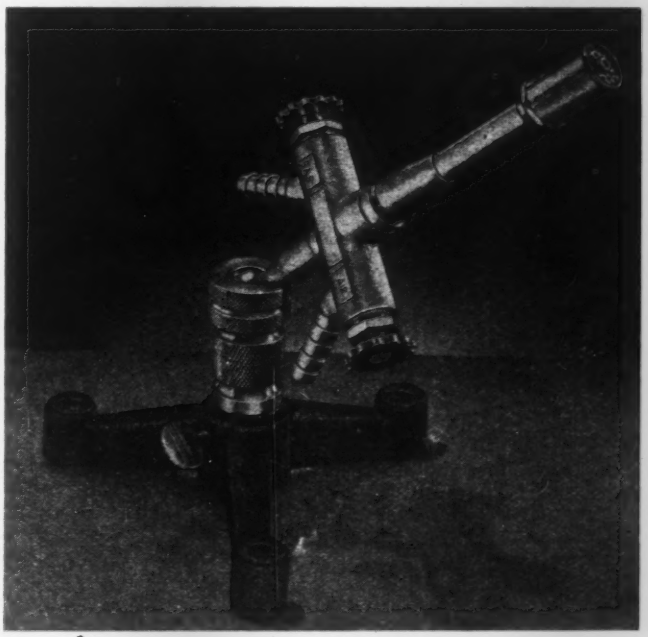


Fig. 3. The Massachusetts Institute of Technology type blast burner. (Photograph through the courtesy of the Precision Scientific Company.)

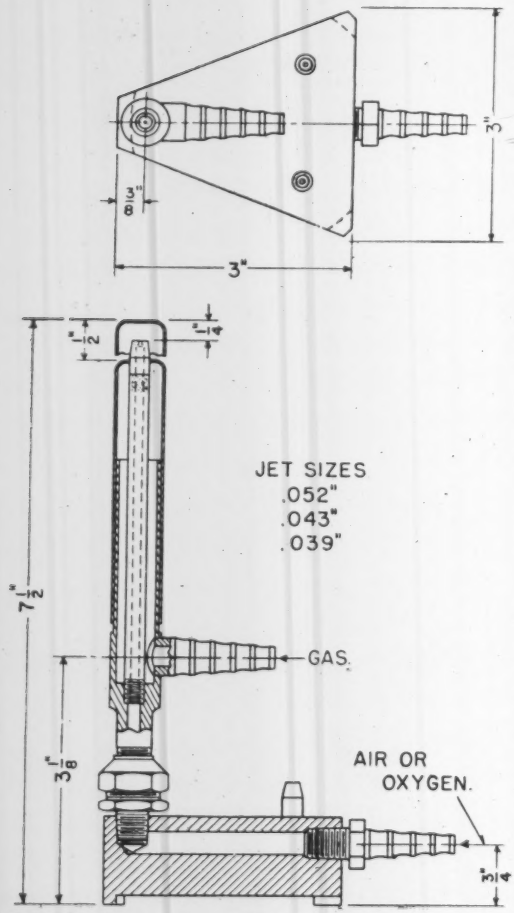


Fig. 4. Special bench burner developed by one of the authors.

Oxygen and gas flow should be regulated until the combustion becomes slightly noisy.

A special bench burner developed by one of the authors is shown in Fig. 4. Critical dimensions are given. The base is shaped as shown to allow one to place the burner close to the edge of the table for side arm work as well as close to glass tube supporting rollers. A ball joint at the base of the nozzle allows movement in any direction or angle. Regulation of gas and oxygen or air flow is controlled by needle valves in the respective manifolds below the edge of the table. The bore sizes for the three jets are given in Fig. 4.

CROSS FIRES

Many types of cross fires are now available, but the laboratory glass shop needs, in general, are met by just four types. The fuel control and temperature attained depend on tubing size and glass compositions being worked.

Glass Jet Cross Fires. Cross fires having glass jets which direct an air stream through a gas flame are ideal for small equipment made of lime or soft glass, Fig. 5. The jets in each bank of burners are made by drawing 13 mm. tubing down to a small capillary bore. These jets are measured conveniently by inserting a small steel needle into the bore and cutting the tip to conform to the same diameter indicated by the needle test. The tips are not fire polished because of the danger of changing the bore size.

The adjustment of this cross fire is important. Each burner in the bank is lined to converge all flames at the center between the two banks of burners. The glass tips are projected into the gas flame ⅜". When properly adjusted all flames will converge in the center and appear to fan out in a plane of 90° to the plane of the jets insuring a narrow working range. Should it be necessary to fabricate micro equipment with Pyrex-brand glass, the glass jets can be replaced with fused quartz jets permitting the use of oxygen instead of air.

Tubular Jet Cross Fires. The tubular jet cross fire is best suited for work in which the prime requisite is a fixed, nonadjustable flame. This cross fire with 2 to 12 jets on each side may be procured with gas valves on each jet. It is commonly used on automatic sealing machines and is shown in Fig. 6.

Laboratory Cross Fire. A cross fire developed by one of the authors for laboratory work is shown in Fig. 7. It is an adaption of the Massachusetts Institute of Technology blast burner modified to converge flames more suitably to cross flames. Unnecessary metal has been eliminated and general overall dimensions are supplied.

This versatile cross fire meets all the requirements in the manual handling of glass. Tubing up to 51 mm. in diameter is conveniently worked by using only the 2 center jets on each side. When larger tubing with diameters from 51 to 100 mm. is being worked, it is necessary to use all jets on both sides. More even heating is also obtained if a single jet blast burner is placed directly below the point of cross fire flame convergence.

The Oxygen and Gas Cross Fire. The oxygen and gas burner shown in Fig. 8 provides a very hot flame which is excellent for working Pyrex glass. A mixer and flash stop device are necessary on this type of burner. If machine shop facilities are not available, this type of burner can be purchased from manufacturers of glass working apparatus.

Economizer Valve. An economizer shown in Fig. 9 should always be used with cross fires because at times it is necessary to shut down the working fire to allow centering and adjusting of the glass being worked. The economizer is essentially a rotary slide valve and is conveniently operated by a foot treadle permitting the use of both hands in handling or rotating the glass.

HAND TORCHES

Hand torches are very useful when glass systems are being assembled. In this work many seals have to be made in

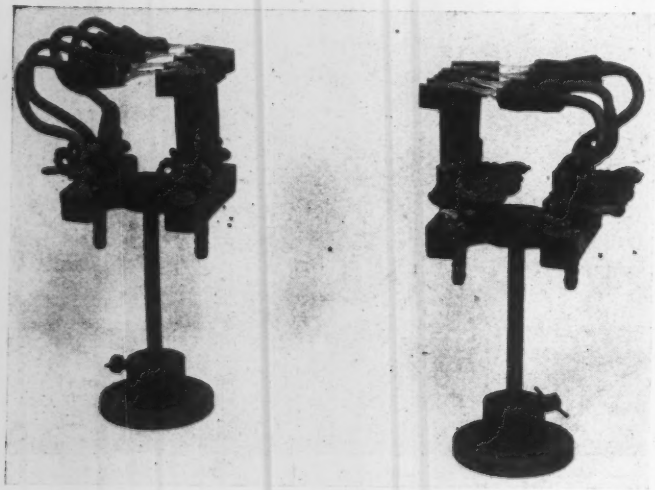


Fig. 5. Cross fires having glass jets, which direct an air stream through a flame.

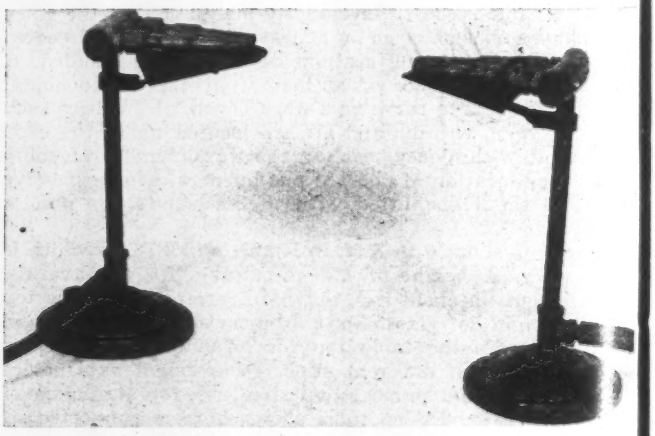


Fig. 6. Tubular jet cross fires.

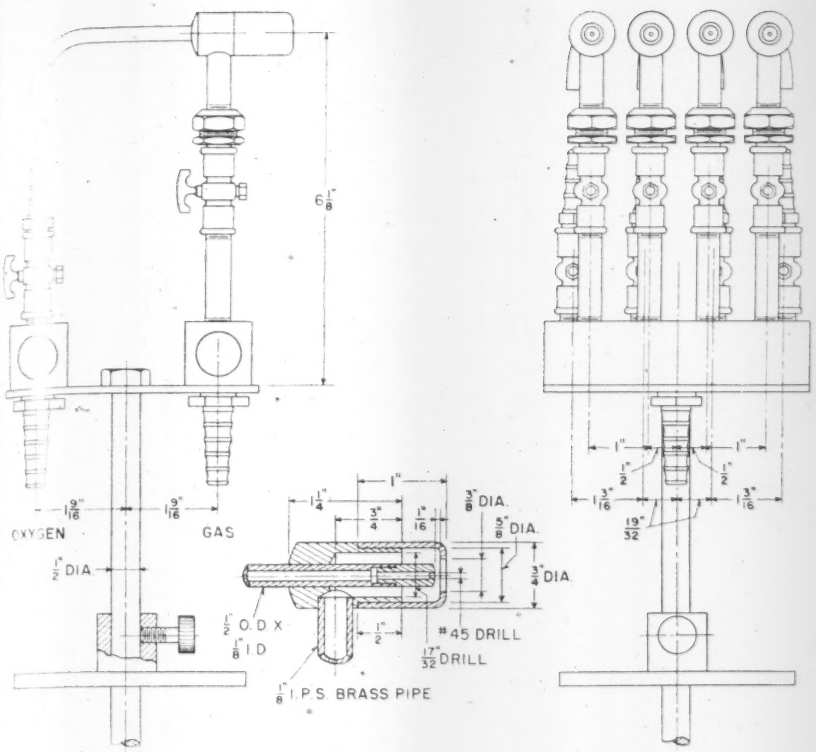


Fig. 7. Laboratory cross fire.

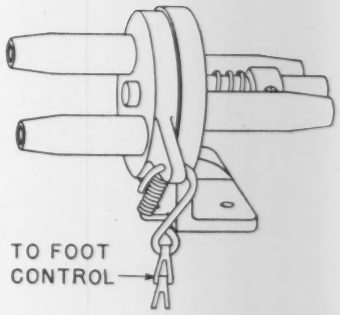


Fig. 9. Economizer valve for use with cross fires.

very close quarters prohibiting the use of the blast burner because of its size. Hand torches also are more conveniently used in tip-off work of small tubulations on large vacuum jackets. Three torches will suffice for all the general work in the glass shop.

Hoke Jewel Torch. Small work, particularly capillary seals are best made with this torch. Interchangeable tips for different flame sizes are usually supplied with the torch. It is also useful in brazing and silver solder work. The torch is shown in Fig. 10.

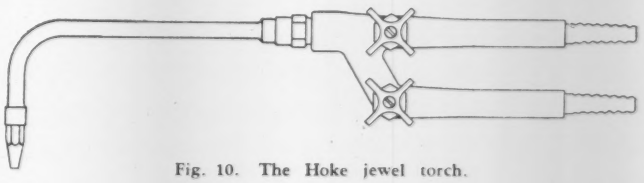


Fig. 10. The Hoke jewel torch.

Litton Hand Torch. The Litton torch has a swivel head and is shown in Fig. 11. It allows close working in making system seals. Higher temperatures for larger seals are obtained with a multiple head torch made by the same manufacturer.

Oxy-Acetylene Torch. Vitreous silica can be handled like ordinary laboratory resistant glass to a reasonable extent with the oxy-acetylene torch. Numerous types of good torches are available. About 6 different tip sizes are necessary. This torch can be mounted by suitable clamps when a stationary flame is required.

RIBBON FIRE BURNERS

The glass blower frequently must make large sweeping bends and, although a large flame in the blast burner can be used, these bends are more conveniently made with the ribbon flame. A slide on the burner, shown in Fig. 12, permits adjustment of flame width from a fraction of an inch to the overall width up to 18 inches. This burner is particularly useful to the "sign bender."

THE ANNEALING AND PREHEATING BURNERS

Annealing Burner. The annealing of glass in a flame is one of the necessary and important duties of a successful glass blower. Numerous strains result in working glass especially when ring seals and connections are made very close together. It is essential from a standpoint of durability that the strains are reduced in magnitude. A good annealing burner is thus an important tool in the routine of working glass.

The annealing burner shown in Fig. 13 will furnish a large bushy flame for uniform heating. Two brass tubes are silver soldered to a common base and act as large jets. Although sufficiently high temperatures for average work

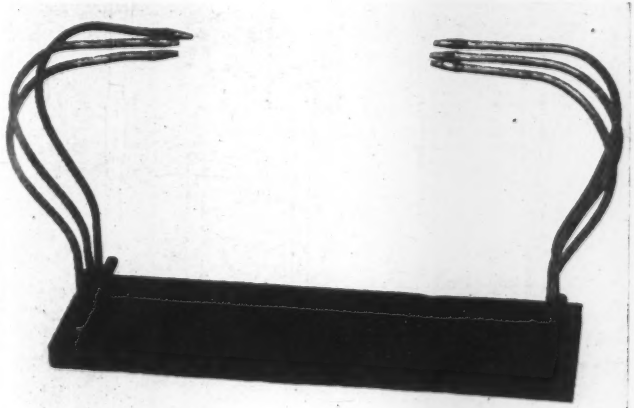


Fig. 8. The oxygen and gas burner which provides a very hot flame.

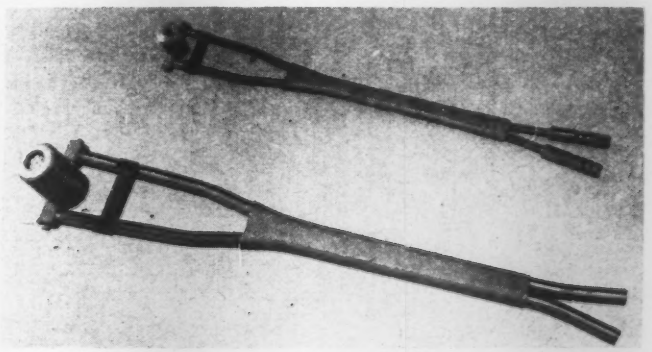


Fig. 11. Litton hand torches with swivel head permitting close working in making system seals.

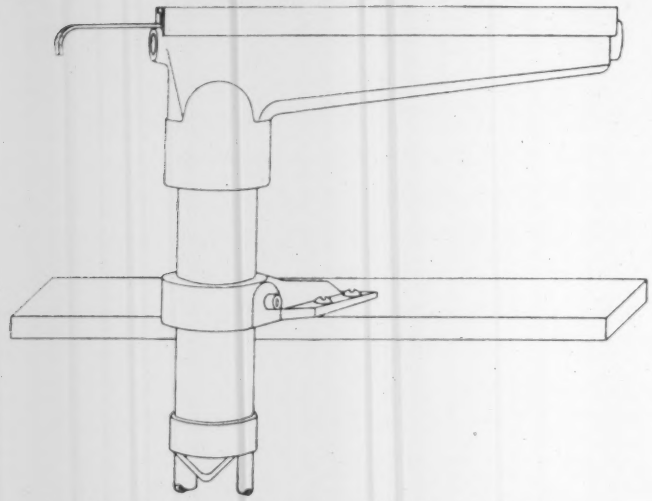


Fig. 12. Ribbon flame burner with slide which permits adjustment of flame width.

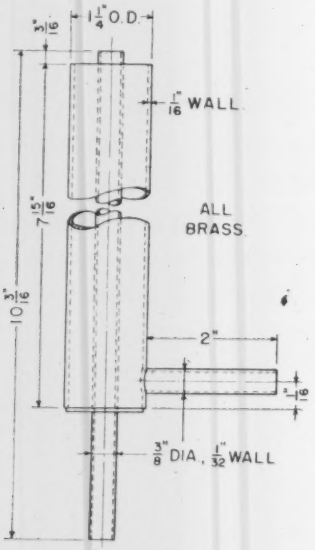


Fig. 13. Annealing burner which furnishes large bushy flame for uniform heating.

are obtained by air and gas, the temperature range may be extended by bleeding oxygen into the air line. The burner should be fitted with globe valves which allow instant opening for rapid heating to prevent cracking while transferring glass from blast burner to the annealing flame. Location of the annealer within reach of the blast burner or cross fires also minimizes loss of heat in the transfer of glass to be annealed.

Preheating Burner. The circular flame of a shielded Argand burner is excellent for preheating or maintaining near working temperatures of complex seals which are to be sealed to other glass sections. The location of this burner should be within easy reach but preferably at the ...r of the table. A small forked support near the burner w... help in holding the glass which is being heated. This bu... is shown in Fig. 14.

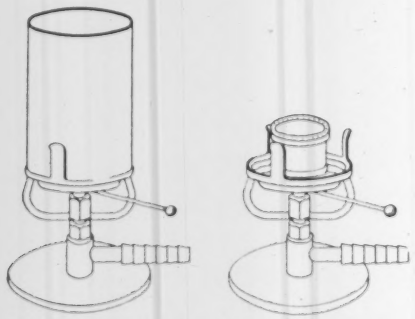


Fig. 14. Argand burner with shield at left, and at right, without shield.

GLASS WORKING TOOLS

Although many tools may be used in working glass ...ile it is being shaped or joined, five tools are sufficient for ...sic work.

Forceps. A balanced steel forceps with an overall le...gth of 10" is shown in Fig. 15a. Transite handles serve as ...ra-ble insulation.

Shaping Tools. Two shaping tools with round Tra...site handles are shown in Fig. 15b. The shaping ends are ...ade of graphite.

Flaring Tools. Two flaring tools are shown in Fig. 15c. The small flaring tool is made of brass with a Transite handle. Beeswax should always be used on the metal flaring tool to prevent adherence of glass. The larger flaring tool is graphite with a Transite handle.

Blowing Tubes. The glass worker frequently has to blow glass; in fact he has found that by repeated collapsing and expanding of fused glass more durable seals can be made. Such a procedure also tends to give even thickness of glass. To permit blowing, several tubes should be made consisting of a glass mouthpiece, rubber tubing of sufficient length and a swivel. The swivels, fabricated from aluminum, permit rotation of the glass without twisting the rubber tubing leading to the mouthpiece. Two different swivels are desirable and are shown in Fig. 16.

Adjustable Rollers. Long and heavy tubing is more easily worked by using adjustable rollers which permit rotation of the glass in the blast burner or cross fire flame with a minimum effort on the part of the glass worker. The set of rollers shown in Fig. 17 utilizes an extension for perfect and rigid alignment, eliminating the necessity of two sets. This double roller is mounted on a heavy base to minimize shifting tendencies while in use. The rolling surfaces which contact the glass are fabricated from Transite and are adjustable to various tube sizes. Critical dimensions are given in the drawing.

GLASS COMPOSITIONS

The glass blower and the scientist alike should be familiar with the physical and chemical properties of glass. Several books and numerous articles have been published in which studies of various glasses are given. The book "Properties of Glass" by George W. Morey[1] is especially recommended.

The trend in research toward finding a perfect glass has been promising in the last thirty years. Pyrex-brand glass first appeared in 1915 as a product of the Corning Glass Works and is almost exclusively used at present in the fab-

[1]Morey, G. W., "The Properties of Glass," Reinhold Publishing Corp., New York, 1938, Chapter I, page 32.

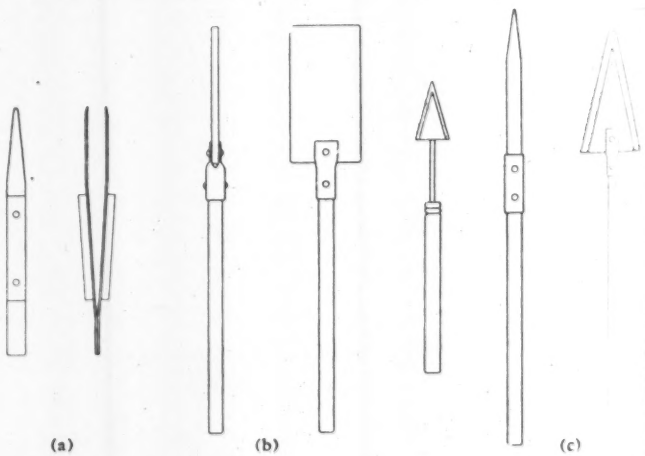


Fig. 15. Glass working tools; (a) forceps, (b) shaping tools, (c) flaring ...

rica[illegible]on of equipment for the laboratory. In 1939 H. P. Hoo[illegible] and M. E. Nordberg of Corning Glass Works developed a p[illegible]cess in which a glass of 96% silica content is made. Thi[illegible] glass is comparable to vitreous silica in withstanding ext[illegible]me thermal shock and with its higher softening point has [illegible]iven the scientist an additional durable glass for scientifi[illegible] quipment where relatively high temperatures are used.

[illegible]ass, according to Morey[1], is defined as follows: "A glass is a [illegible]inorganic substance in a condition which is continuous with[illegible] and analogous to, the liquid state of that substance, but [illegible]hich, as a result of having been cooled from a fused cond[illegible]ion, has attained so high a degree of viscosity as to be for[illegible]l practical purposes rigid." In this definition it is inferr[illegible] that glass has no definite solidification or freezing poin[illegible], but has attained solid characteristics through a tremen[illegible]us increase in viscosity and not through the process of cr[illegible]ystal formation.

Glass compounding is best understood by phase equilibrium studies of the numerous systems of glass-forming components. Certain combinations of inorganic compounds have been found to give good laboratory glasses and only through a thorough study of the phase relationships at various temperatures can one become familiar with the phase changes to be expected in working the glass. It will suffice here to mention some of the more important glass-forming compounds and to briefly point out the advantages in using some of them in compounding glass.

The most important inorganic compounds in making laboratory glasses are the oxides of silicon, boron, aluminum, sodium, potassium, calcium, magnesium, lead, barium, zinc and iron. Silicon dioxide (SiO_2) is the basic component in nearly all laboratory glass ranging from 65% to 100% of the total glass. Because of the high melting temperature of silica (1710°C.) it has been found advantageous to add oxides of boron, aluminum, sodium and potassium to lower the liquidus temperature, a temperature above which no crystallization can take place. However, the addition of the latter two oxides has a tendency of increasing the coefficient of expansion and glasses containing large amounts of these substances are also subject to attack by water and acids. It has been found advantageous to use only small amounts of the oxides of sodium and potassium. Alumina in a small quantity gives the glass a greater chemical stability and lowers the coefficient of expansion.

The compositions of various laboratory and resistant glasses according to Morey[1] are given in Table 2. It is interesting to note that the development of laboratory glass is shown in this table and that all glasses contain numerous components. Pyrex-brand glass which is most widely used in the laboratory is characterized by a very high silicon

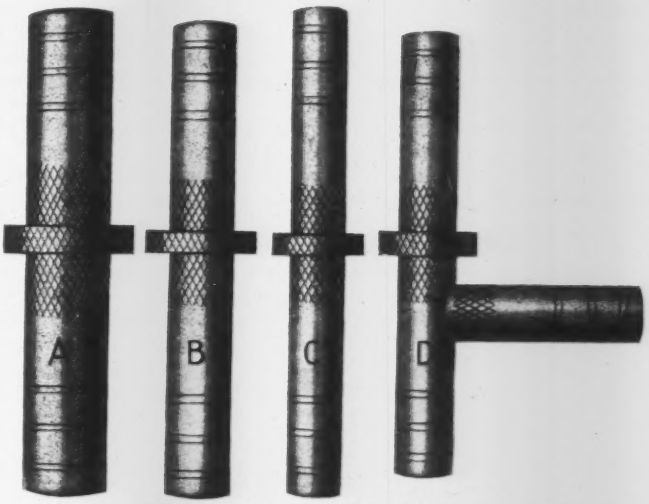


Fig. 16. Swivels to permit rotation of the glass when blowing without twisting the rubber tubing. (Photograph courtesy of Eisler Engineering Co.)

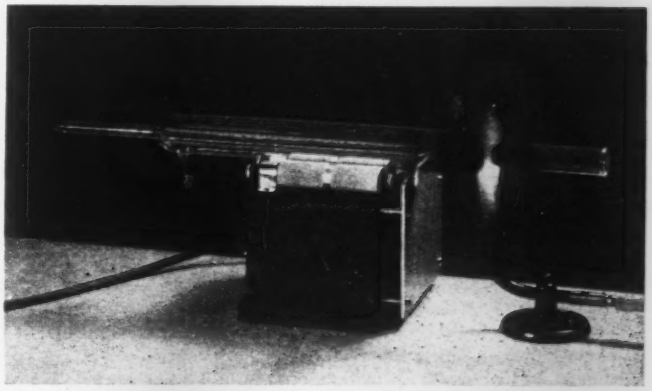


Fig. 17b. Electrically driven rollers for even and uniform heating. (Photograph courtesy of Fisher Scientific Co.)

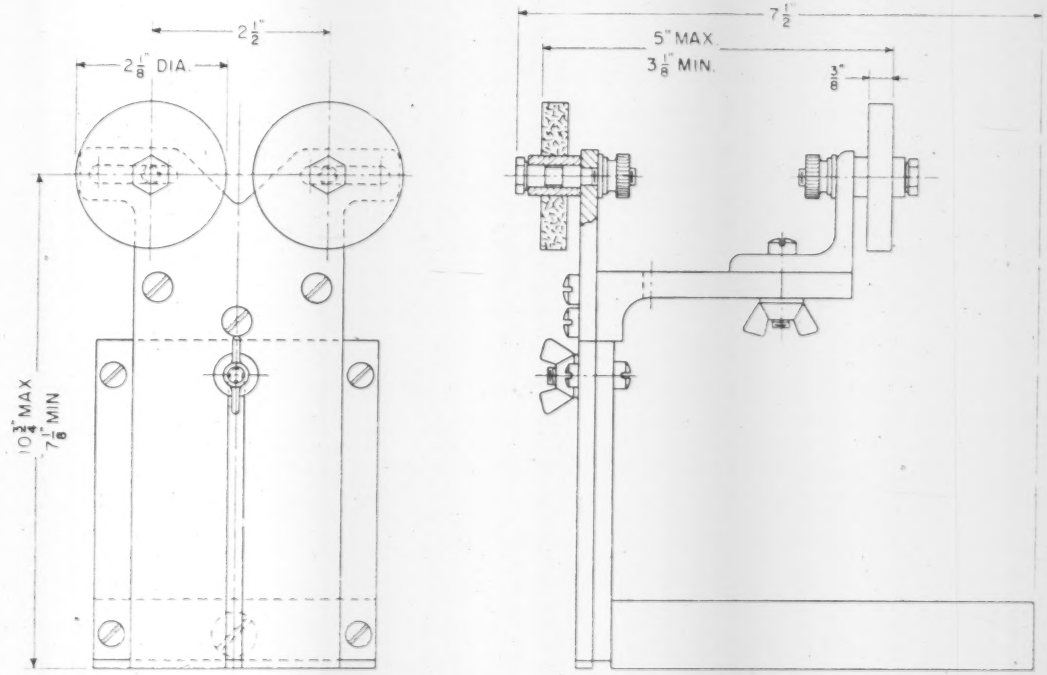


Fig. 17a. Adjustable rollers used for working long and heavy tubing.

dioxide content, and yet it has the lowest liquidus temperature of any glass having such a high content of this oxide. It is because of this fact that the glass blower has very little devitrification trouble in working Pyrex-brand glass.

Lime-soda glass is still used in many types of graduate vessels. Equipment which is subjected to thermal shock should not be made of this type glass. The chemical stability also is not as good as that of Pyrex-brand glass. It is more convenient to use the same type of glass in laboratory equipment especially when graduated vessels are sealed to glass assemblies. Because Pyrex-brand glass offers more durability, it is recommended over lime-soda glass. Simpler pieces of apparatus may be constructed of the latter type

TABLE 2.

Compositions of Some Laboratory and Resistant Glasses

No.	SiO_2	B_2O_3	Na_2O	K_2O	MgO	CaO	ZnO	Al_2O_3	Fe_2O_3
1	77.0		5.0	7.7		10.3			
2	79.4		6.4	6.7		7.6			
3	75.9		7.1	7.9	0.17	8.7		0.14	0.08
4	66.4	4.0	15.6		5.2		6.2	2.4	
5	64.7	10.9	7.5	0.37	0.21	0.63	10.9	4.2	0.25
6	73.0	3.6	10.8	0.30	4.3	0.66	5.6	1.0	0.35
7	67.3	6.2	10.9	0.30	3.4	0.79	7.8	2.5	0.23
8	66.80	4.13	7.40	1.75	2.60	1.73	9.75	2.54	0.17
9	75.90		7.29	7.84	0.15	8.73		0.24	0.10
10	76.20		7.07	7.62		8.97		0.30	0.14
11	74.32		17.56	1.38	0.11	3.67		2.35	0.14
12	77.9	14.1	4.1	2.3		0.8		0.8	
13	81.5	11.0	3.7	0.9		0.3		2.8	
14	81.4	10.6	4.4	1.1		0.7		2.0	
15	75.3	15.8	3.4	1.0		1.3		2.5	
16	75.4	17.5	3.6	0.4		0.1		1.6	
17	75.3	7.6	5.7	0.8		1.1		6.2	
18	57.4	23.6	1.9	0.5	8.7	4.7		3.2	
19	75.6	14.3	3.3	0.4		0.1		5.6	
20	80.5	12.9	3.8	0.4				2.2	

1. Stas' apparatus glass. Glass No. 73, D. E. Sharp, *Industrial & Engineering Chemistry*, Vol. 25, 1933,. page 755.
2. Kavalier glass, 1879. Glass No. 74, D. E. Sharp, *Industrial & Engineering Chemistry*, Vol. 25, 1933, page 755.
3. Kavalier beaker. P. H. Walker and F. W. Smither, Technical Paper No. 107, National Bureau of Standards, 1918. Also contains MnO, 0.02; P_2O_5, 0.08; SO_3, 0.20; As_2O_5, trace.
4. Jena Gerate, prior to 1910. Glass No. 75, D. E. Sharp, *Industrial & Engineering Chemistry*, Vol. 25, 1933, page 755.
5. Jena Gerate beaker. P. H. Walker and F. W. Smither, Technical Paper No. 107, National Bureau of Standards, 1918. Also contains MnO, 0.01; As_2O_5, 0.14.
6. Macbeth-Evans beaker, 1918. P. H. Walker and F. W. Smither, Technical Paper No. 107, National Bureau of Standards, 1918. Also contains MnO, 0.02; SO_3, 0.02; As_2O_5, 0.02; Sb_2O_3, 0.60.
7. Nonsol beaker, 1918. P. H. Walker and F. W. Smither, Technical Paper No. 107, National Bureau of Standards, 1918. Also contains MnO, 0.01; Sb_2O_3, 0.62.
8. Kohln-Ehrenfeld. J. D. Cauwood and W. E. S. Turner, *Journal Society Glass Technology*, Vol. 2, 1918, page 219. Also contains As_2O_3, 2.05; Sb_2O_3, 1.29.
9. Resistance, "R." J. D. Cauwood and W. E. S. Turner, *Journal Society Glass Technology*, Vol. 2, 1918, page 219. Also contains As_2O_3, trace; MnO, 0.13.
10. Zsolna. J. D. Cauwood and W. E. S. Turner, *Journal Society Glass Technology*, Vol. 2, 1918, page 219. Also contains Sb_2O_3, 0.30.
11. Japanese. J. D. Cauwood and W. E. S. Turner, *Journal Society Glass Technology*, Vol. 2, 1918, page 219. Also contains MnO, 0.10.
12. Silex. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193.
13. Vulkanite. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193.
14. Resista, 1923. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193.
15. Resista, 1925. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193.
16. Tempax. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193. Also contains Sb_2O_3, 1.6.
17. Jena Gerate, 1920. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193. Also contains BaO, 3.5.
18. Jena Supremax, 1565III. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193.
19. Jena Durax 3817III. H. Thiene, *Zeitschrift fuer angewandte Chemie*, Vol. 39, 1926, page 193. Also contains Sb_2O_3, 0.4.
20. Pyrex chemical resistant glass.

glass and if a supply of oxygen is not availab it is necessary to use this glass because it can be readily orked with air and gas.

Lead glass is being used extensively in rare gas tubes and fluorescent lighting. It is particularly useful the glass to metal seals required in their construction This type of glass is easily scratched and is attacked by a umber of chemical reagents. In working lead glass a st nger oxidizing flame is recommended; otherwise reduced lead will blacken the seals. Seals started in tubing with bla ened edges will leak and no amount of working eliminat the lead. A slight darkening on the outside will disappear f the glass is held in the tip of a flame containing an excess f air.

Vycor-brand glass which contains 96% silica with boric oxide and traces of the oxides of aluminum and iron as the remaining ingredients is produced by the specialized leaching process by Corning Glass Works. It is marketed under their code numbers of 790 and 792. The former is transparent and can be used up to a temperature of 900°C. The 96% silica glass 792 is translucent and can be used to a temperature service limit of 800°C. Both glasses have a low linear coefficient of expansion and have softening points at about 1500°C.

The chemical resistant glass known under the trade name of Pyrex is used extensively for a general all-purpose glass in the laboratory. As was shown in Table 2 it is a borosilicate glass having a low potassium and sodium oxide content. This glass is listed under the Corning Glass Works Number of 774, has a softening point of 820°C. and can safely be used in repeated heating operations up to 600°C. Its linear coefficient of expansion is four times that of Vycor-brand glass.

An alkali resistant glass known as "Corning" 728 which is boron-free is used when resistance toward alkalies is desirable. This glass has a linear coefficient of nearly twice that of Pyrex-brand glass and consequently should not be used when resistance toward thermal shock is desired. This glass has a softening point of about 870°C.

PROPERTIES OF GLASS

The glass blower must be familiar with the coefficient of expansion of various glasses. All glasses are poor conductors of heat and require gradual heating and cooling, especially when equipment with complex seals is changed or repaired. Rapid heating of seals will cause breakage and the beginner must be aware of this fact.

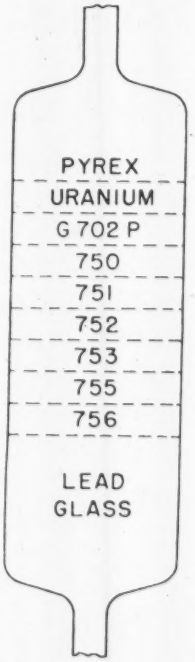


Fig. 18. Series of glasses for sealing lead glass to Pyrex.

In the construction and repair of laboratory apparatus it is necessary to use tubing with the same physical characteristics as the glass from which the apparatus was originally made; otherwise, unnecessary strains due to uneven expansion may cause subsequent breakage. The low thermal expansion coefficient of Pyrex-brand glass permits heavy and rugged construction thereby increasing the resistance to mechanical breakage. This glass is well within our working range and is used extensively for laboratory apparatus. Contrary to popular belief, the manipulation is less difficult than soft glass if provision is made for efficient burners. It would be impossible to duplicate the more complicated equipment which is now made of Pyrex-brand glass by substituting soft glass, and furthermore, the apparatus would fail under conditions which are imposed upon it.

The glass blower must also have information about the coefficient of expansion of the glasses when he is required to seal two different types together. As an example, suppose a certain piece of equipment of lead glass is to be sealed to Pyrex. It would be impossible to seal the two directly to-

geth ; instead, a series of thin and well annealed seals are mad n the order shown in Fig. 18. Here the coefficient of expa sion of each glass, for which the code number of the Corn g Glass Works is given, range in respective order betw n that of lead glass and Pyrex.

A comparison of the relative linear coefficient of expansion f several glasses is given in Fig. 19. The increase in lengt shown by the dotted portions corresponds to a

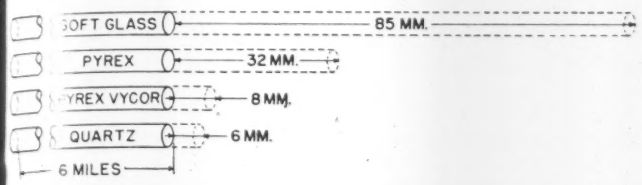


Fig. 19. Increase in length of various glasses with increase in temperature of 1°C.

temperature increase of 1°C. The coefficients of expansion, as well as the softening, annealing, and strain points of several Corning glasses are given in Table 3.[2]

A knowledge of the chemical durability of glasses is important when scientific equipment is made. Pyrex-brand glass or Vycor is adequate for nearly all general purposes except when strong and hot alkali solutions are continually used in the apparatus. Under such conditions "Corning" 728, an alkali resistant glass, may be advantageously used. It has been found more practical however to use Pyrex-brand glass in assemblies which are exposed to alkalies because it is often easier to replace the exposed parts than to use a different type of glass which requires graded seals in connecting it with the remainder of the assembly.

Devitrification

Devitrification was a constant threat in the development of glass for the laboratory but by accurate compounding of glass this danger of crystal formation has been greatly eliminated. Usually when frosting of the surface appears in "Pyrex" seals, it is not the cause of the glass composition but instead the carelessness of the worker. The glass blower finds that the danger of causing devitrification is greatest when force is exerted on a seal at the time when the red glow is departing from the glass prior to annealing. Experience in working glass is the best way in learning to prevent devitrification, and the beginner may find it helpful by noting what method of handling causes frosted seals.

[2]Phillips, C. J., "Glass: The Miracle Maker," Pitman Publishing Corp., New York, 1941, Chapter VIII, page 183.

Cutting Glass

Consideration must be shown to the composition of the glass in operations which involve cutting. Some cuts made on soft glass (lead or lime-soda) would fail on Pyrex and certain techniques used on Pyrex would cause serious trouble with soft glass. Undoubtedly, the harder the glass, the more patient one must be. The difference lies in the fact that soft glass breaks too easily and especially when one tries to duplicate the diagonal and slot cuts made on Pyrex with a carborundum wheel.

Glass tubing in sizes ranging from minute capillary up to approximately 25 mm. o.d. should be scratched by an abrasive instrument and then broken apart by the use of both hands. Whether one uses a steel wheel, a glass knife or a three-cornered file, the technique is the same. The scratch is made cleanly, perpendicular to the tubing, and it is not necessary to try to saw through it. Expert flat glass cutters make only one scratch, but on tubing it is best to scratch the glass twice. If the abraded surface is

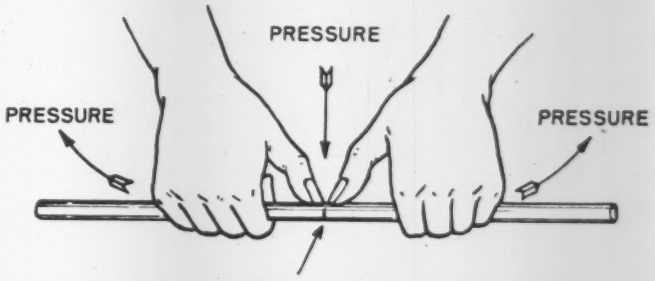


Fig. 20. Method of breaking tubing 13 mm. and smaller.

wetted with water, it will break more easily. Usually glass blowers employ this trick but cannot explain why the glass is weakened. Milligan[3] has shown that the tensile strength is decreased by wetting glass containing a small crack. After scratching and wetting, the thumb nails are placed against the back of the tubing for a fulcrum directly opposite the scratch. The break is then made by a combined bending and pulling force back and away from the mark, Fig. 20. It should be pointed out that files and cutting wheels are only effective when new and sharp, and tungsten carbide-edged knives must be resharpened continually.

For 13 to 25 mm. tubing a different hand hold is advisable. The glass tube is scratched, wetted and grasped in a full grip with a hand on each side of the mark. Each

Continued on page 906

[3]Milligan, L. H., *Journal Society Glass Technology*, Vol. 13, 1939, page 35.

TABLE 3. Some Sealing Glasses Manufactured by Corning Glass Works, Corning, New York

From	Sealing Glass Series						To
	Code No.	*Lab. No.*	*Expan. × 10⁷*	*Soft. Pt. (°C)*	*Anneal. Pt. (°C)*	*Strain Pt. (°C)*	
Fused silica (5.5-5.8) No. 790	790	790-H	8. ± ⅓	1510 ± 30	890 ± 20	790 ± 20	
	723	707-GS-1	13.5 ± 1	1160 ± 20	750 ± 20	675 ± 20	
	720	707-GU-1	19. ± 1	1125 ± 20	645 ± 20	583 ± 20	
	724	715-AO	21. ± 1	840 ± 10	583 ± 10	514 ± 10	No. 774
	774	726-MX	32-33	819	553	510	
No. 774	772	702-P	36	756	526	494	Tungsten (45)
	705	705-AJ	46	703	496	461	Kovar } —(47)
Kovar }	704	705-BA	49	697	484	450	Fernico }
Fernico }	706	705-AO	50	693	494	459	
Molybdenum	752	750-AJ	62	747	566	530	Molybdenum
	753	805-F	70	728	557	528	(53-55)
	755	805-G	77	716	546	516	
	756	750-AL	85-88	702	536	503	G-1, G-12
	012	G-12	87	630	431	395	Platinum (90)
	001	G-1	90	626	425	389	Nickel irons (90)
	008	G-8	92	696	510	475	Chrome irons (100)
							Dumet
G-1 & G-12	025	125-AJ	98.6	648	464	433	Allegheny type (110)

Numbers in parentheses represent approximate linear expansion/°C. × 10⁷.

ELECTRIC GAGING METHODS for Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

XVI. POWER SUPPLIES.

§1. General.

All electric gaging systems require some external source of energy; in general this energy is introduced in the form of electric power, and the measuring system acts merely as a valve to control the amount of energy reaching the indicating or recording device. (The generating-type primary elements absorb mechanical energy which is converted by the transducer into electric energy.) The means for supplying the required electric energy must be considered as part of the general requirements for any electric gaging system. In this chapter the basic requirements for power supplies will be discussed.

Three requirements ordinarily are imposed on any gaging-system power supply; they deal with (1) type of output, (2) magnitude of output, and (3) stability of output.

The type of output depends upon the type and form of the gaging system; if it is a resistance-type system of the most elementary form, for example, it will require only direct current and there may be no need for accurate regulation. If it is a variable-inductance system utilizing a deflection method, it will require excitation by alternating current which must be accurately controlled as to potential, and perhaps also in frequency. (See Fig. 45, Part I.) A once-popular—and still used—form of capacitance type system employing the half-resonance-curve method (see Fig. 25, Part I) requires also a constant-frequency constant-voltage source; in this instance it must be a radio-frequency source. The null methods do not impose any requirement for constancy of output voltage on the power supply (this is one of their major advantages) but they often do require constant frequency and good wave-form.

With *any* amplified system it is necessary to supply energy to the amplifier; this ordinarily requires low-voltage alternating or direct current for heating the cathodes of the electron tubes, and a high-voltage d-c. supply for the anode (plate) circuits. Either or both may require regulation.

When a frequency other than that of the power line is required, the problem also includes the generation of that frequency and its amplification to the needed power level.

Because of the widespread use in this country of the standard public utility frequency of 60 cycles per second (in a few localities 25-cycle and 50-cycle systems are still used) and because this is easily converted by transformers to the commonly-used 117 volts, it is convenient to design all except special equipment to operate from this source. When other prime sources must be used, converters may be procured to change the available power to 110-volt 60-cycle power.

§2. A-c. Power Supplies; 60-cycle

For many applications, the 60-cycle line frequency is satisfactory, either with or without voltage regulation. Such circuits as the water-level indicator of Fig. 45 (Part I) and many of the null-method inductance bridge circuits can quite well be operated with 60-cycle exciting current. Regulation of the voltage is necessary if a deflection method is used; not with a null method.

The use of the transformer for converting alternating current from one voltage to another is so well known as to need no mention; as is the use of the variable autotransformer, which provides a continuously-adjustable output potential. In recent years the voltage-regulating transformer has come into wide use, making available not only any desired output voltage but also one which does not vary appreciably with either input voltage or load. These transformers are standard commercial products, available from a number of manufacturers.

The voltage-regulating transformer has one characteristic which is a serious disadvantage for gaging applications. Since its regulating action depends (usually) upon the combined effects of a tuned circuit and a saturable reactor, its output current often has a seriously distorted wave-form—and one which varies with load. Any gaging system which requires either accurate frequency control or good wave-form for the exciting current will probably not operate well with such a transformer supply. Recently a new type of voltage-regulating transformer has been produced which is said to be entirely free from this defect. It is not yet available for general use.

A simple circuit for such a voltage-regulating transformer is given as Fig. 23; here the load current passes through a coil surrounding one transformer core so proportioned as to saturate when the load current is too high, while a roughly resonant tuned circuit is provided by the other transformer and the capacitor *C*.

All those voltage-regulating devices which employ resonant circuits are sensitive to variations in frequency of the

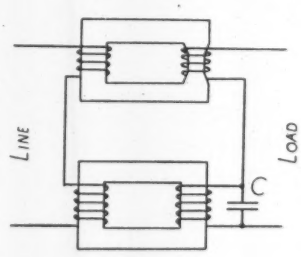


Fig. 23

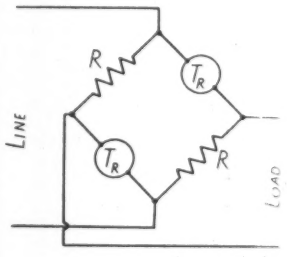


Fig 24

supply voltage, and so cannot well be used on circuits where the frequency is not controlled. They are not satisfactory for field operation with portable gas-engine generators.

For small amounts of power, regulation can be provided by means of the non-linear bridge circuit shown in Fig. 24; it employs two fixed resistors *R* not changing in resistance with temperature changes, and two thermistors, T_R, which do change rapidly in resistance with temperature changes. Such a bridge circuit can supply closely-regulated direct or alternating current (or potential) to a fixed load; it is rather inefficient but it does not distort the wave-form of the current. Another method occasionally used employs a gas-discharge tube as a reference element, and provides regulated a-c. potentials which may be adjusted to any desired value by means of a transformer. (See Fig. 82, Part I.) Gaseous-tube regulators distort the output wave-form when they are used in a-c. circuits.

Portable supplies for producing small amounts of a-c power are available; for a few hundred watts or less of power vibrator-type inverters are available, with storage batteries as the prime source of power; for larger amounts of power, gas-engine generators are available. Of these, the vibrator-type inverter is ordinarily the more constant in frequency, but less perfect in wave-form.

§3. High-frequency A-c. Power Supplies.

Alternating-current power supplies of frequencies higher than 60-cycle are required for capacitance-type systems, because their impedance is prohibitively high at lower frequencies. High-frequency excitation is also used with resistance-type and inductance-type gaging systems when it is desired to measure and record at any frequencies except the very lowest. Gaging systems in which the mechanical magnitude is caused to modulate a carrier frequency are usable up to perhaps 25% of the carrier frequency, but not higher.

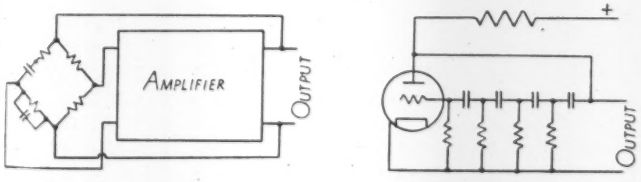
V iable-inductance systems for dynamic measurement emp y carrier frequencies from 1,000 to 10,000 cycles per seco d; variable-capacitance gaging systems may employ car r frequencies as high as several megacycles. For the low ranges of frequency, either mechanical or electronic gen ators may be used; for the higher frequencies mec nical generators are not available. Piezoelectric (me anico-electric) crystals may be used to control the freq ncy of radio-frequency oscillators.

M chanical (rotary) generators are used to generate pow for gage circuits at frequencies as high as 5,000 cycl per second. Their efficiency at higher frequencies falls off seriously; even at 5 kc. there is some difficulty in main aining good wave-form without contamination by spur ous frequencies. Regulation of the frequency of output of a mechanical generator is accomplished by adjusting the speed of rotation; magnitude of output by adjusting field strength.

For gaging applications the present practice is to employ electronic generators for a-c. excitation. Such generators can be constructed to supply as much as 2 kilowatts or as little as 2 watts, thus accommodating virtually any need. They are more bulky in the larger sizes than the mechanical generators, weigh about the same, and have a number of advantages over the rotary generators. Among these advantages are purity of wave-form, variable-frequency operation if desired, extended frequency range (from 100 cycles to 100 kilocycles), and the fact that such generators can easily be equipped with regulating circuits so that their output will not suffer from variations in either load or supply voltage. Many multi-channel electric gaging systems nowadays employ amplifiers on all gage circuits, and require only minute quantities of power for excitation. An electronic generator occupying a volume of only one-tenth cubic foot can supply enough exciting energy, with almost perfect wave-form, for a dozen amplified gaging circuits.

Such electronic generators incorporate two or three sections: a master oscillator, a power amplifier, and often an auxiliary regulating circuit which maintains the output voltage constant under all normal conditions of operation. Energy must also be supplied to operate the electron tubes comprising these circuits.

The master oscillators employed in these devices may employ any of several basic circuits; those most often used for the audio-frequency range (100 to 20,000 cycles per second) are the Wien bridge oscillator and the phase-shift oscillator. The general forms of these two circuits are sketched in Figs. 25A and 25B. The Wien bridge circuit employs a resistance-capacity network sharply tuned to a single frequency and allowing only that frequency to pass through a regenerative amplifier circuit; the phase-shift circuit employs a phase-shifting resistance-capacity network which produces a fixed time-lag in any signal fed back through a regenerative amplifier, so that only the single frequency having a period corresponding to this time-lag is finally amplified.



A B

Fig. 25

There are two popular and effective circuits in use for regulating the output of electronic power supplies against changes in either load or supply voltage. One requires the installation of extremely large percentages of negative feedback, taking the feedback voltage from the load circuit. Then, if a constant-voltage signal is amplified, the feedback circuit tends to keep the output voltage constant even though the load changes. The other circuit incorporates a biassed rectifier circuit connected across the load circuit: So long as the output voltage is below the bias voltage, the rectifier does not operate, and the amplifier gain is increased. As the output voltage increases to the point where it "spills over" and the rectifier operates, the resulting rectified potential is applied to a control stage and the gain of the amplifier is reduced. In operation, the circuit stays at the level where the biassed rectifier is just "spilling over" and the control stage is always in operation.

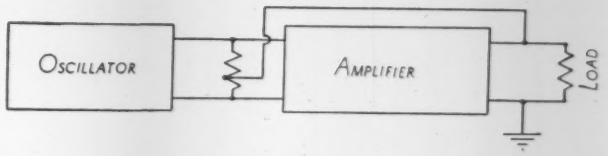


Fig. 26

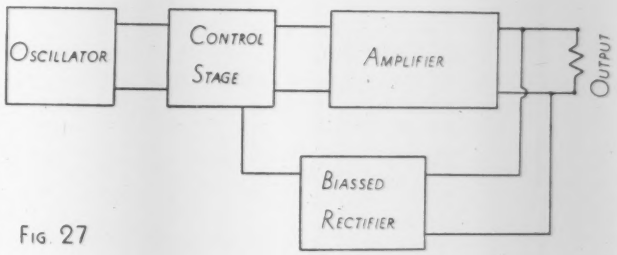


Fig. 27

Block diagrams of these two circuits are here given: Fig. 26 represents the negative feedback circuit, and Fig. 27 represents the biassed-rectifier circuit.

For design data on circuits such as these, handbooks and textbooks are available. The descriptions given here are intended merely to indicate the principles employed.

A commercial power supply, designed to operate a multi-channel strain-gage equipment, and including two regulated d-c. supplies and one regulated audio-frequency a-c. supply, is shown in Fig. 28. It may be operated from 110-volt 60-cycle line current, or from storage batteries for portable operation; mechanical inverters convert the battery power to a-c. for portable operation. (This power supply is used in conjunction with the equipment illustrated in Fig. 35. Another somewhat similar power supply, also a part of a complete strain-gaging equipment, is shown in Fig. 33; it is the upper deck of the apparatus shown in the photograph. This power supply operates only from 110 volts as a prime source of power.)

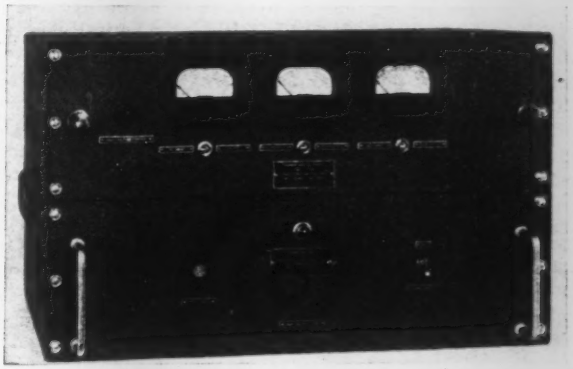


Fig. 28. Combined A-c. and D-c. Power Supply for Strain-gage Amplifiers. *(Courtesy Hathaway Instrument Company.)*

§4. Low-voltage D-c. Power Supplies.

Low-voltage* direct current is conveniently supplied by storage batteries, or by transformer-rectifier sets, if no regulation is required. Accurate regulation of low-voltage d-c. supplies is required in only a few instances; this is a convenience, since few methods for accomplishing such regulation are available.

*Below 10 volts.

If little or no current is required, as for biassing the control grids of electron tubes, it is satisfactory to produce a higher voltage by one of the methods to be described in the next section, then placing a potential divider across this supply. The constancy of potentials thus produced depends of course upon the high-voltage supply and upon the stability of the voltage divider. The method is invalid unless the load current is constant.

For higher currents, it is satisfactory to employ a rectifier-filter arrangement, with regulation applied to the a-c. supply. The a-c. input may be regulated with a constant-voltage transformer, if the d-c. load is constant; if the load is variable, it is possible to employ an electronic regulating circuit. One such circuit, capable of controlling voltages to almost any desired order of accuracy, employs a form of d-c. potentiometer as a detecting device, and applies regulation to the a-c. input in accordance with the variations in d-c. output. Fig. 29 illustrates the form of

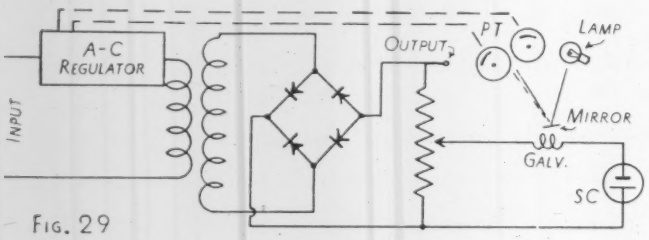


FIG. 29

this circuit; the output voltage at the load circuit is balanced against the potential of a standard cell, and any difference indicated by a galvanometer deflection. The deflected light-beam of the galvanometer impinges upon a pair of phototubes, *PT*, which supply a signal by means of which the controlling device may be commanded. The device controlling the amount of a-c. power admitted may be a saturable reactor, or some other convenient device. The output of the phototubes could be applied to the grids of triode-type rectifying electron tubes. Photocells could be used instead of phototubes. The circuit is actually no more than a refinement of the familiar carbon-pile regulator in which the output potential acts upon an electromagnet to alter the pressure applied to the carbon pile and thus to alter its resistance. The carbon-pile regulator is not a precision device; the circuit described above may be made as sensitive as desired by selecting a suitable galvanometer.

Most low-voltage d-c. requirements in gaging work do not require closely regulated potentials, or if close regulation is required it is ordinarily in a circuit with a constant load, so that the regulation problem is easily solved.

§5. High-voltage D-C. Power Supplies

One of the principal uses for accurately-regulated d-c. supplies at high voltage is for providing plate current for measuring amplifiers, or for oscillators where constant output is required. The widespread adoption of such amplifiers has contributed to the development of regulating devices for direct current at high* voltages. There are two convenient and satisfactory systems available — gaseous-tube regulators and electronic regulators.

*From 100 to 1,000 volts.

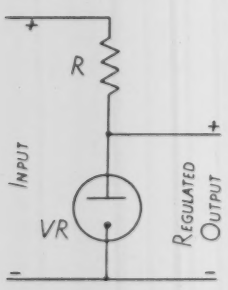


FIG. 30

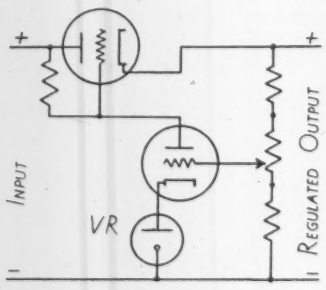


FIG. 31

A gaseous-tube regulator is simply a gas-filled diode so constructed as to maintain during operation a constant potential between its two electrodes; the magnitude of this potential depends upon the composition and pressure of the gas, and the form of the electrodes. Tubes are available which have potential drops varying from about 65 volts** to about 180 volts, and several tubes can be placed in series for higher voltage operation if that is needed. Parallel operation is not usually successful. A typical circuit is shown in Fig. 30; the regulating action depends upon the presence of the resistor *R*, which controls the current through the regulator tube *VR*. The potential between its electrodes will remain constant so long as the current flowing remains within the operating limits.

The electronic regulator circuits in general use employ electron tubes as series elements; the voltage available at the load terminals is raised when necessary by reducing the tube resistance, and lowered when necessary by the inverse process. The needed alteration in the resistance of the tube is accomplished by altering the potential of the control grid. For extremely close regulation (0.005 volt) the output potential is balanced against a fixed potential (derived either from a battery or from a gaseous regulator tube) and these variations, after amplification by a one- or two-stage amplifier, are applied to the control grid of the regulating tube. Accurate and extremely rapid control is possible by this method. For less precise regulation, the amplifiers may be omitted, but they add so little in cost and in complexity to the power supply that they are nearly always included. A number of commercial power supplies of this type are available, supplying voltages from a few volts to several thousand, and currents as high as an ampere. The basic circuit of this type of regulator is shown as Fig. 31.

XVII. AMPLIFIERS AND COMPUTING DEVICES.

§1. General.

The need for amplifiers in electric gaging devices requires no explanation; their function is simply to increase the amount of energy available from a primary element to an amount sufficient to actuate an indicating or recording instrument. Through their use some operations are made possible which otherwise would be beyond the ability of available equipment—for example, the use of low-level primary elements, which can be made much smaller, lighter, and capable of more varied installations than the high-level gages which do not require amplification.

Amplified systems can also be made capable of certain types of performance which are beyond the capabilities of non-amplified systems; integrating and differentiating devices may be employed only if amplifiers are available, since in their operation they attenuate the electrical signal so greatly that further amplification is then required.

For performing some other electrical computations, amplified systems are required, too; they more than make up in convenience and flexibility for their disadvantages in complication of design and construction.

Several different types of amplifiers are available; they differ in construction and in manner of operation, and differ too in their most effective applications. The most widely used is the resistance-capacitance coupled* audiofrequency amplifier, which can amplify electrical signals over a frequency range from one or two cycles per second up to about 20,000 cycles per second. (Present-day practice in amplifier design employs resistance-capacitance coupling between all stages not required to deliver appreciable amounts of power.) There are also direct-coupled amplifiers, which respond to steady-state input signals as well as to a-c. signals; these are required when it is necessary to measure and record phenomena covering a frequency range extending from steady-state conditions up to relatively high frequencies; and there are carrier-type amplifiers, which can effectively amplify low-frequency and

**Some workers have reported successful use of mercury-vapor or argon-filled rectifier tubes as low-voltage gaseous-regulator tubes; the arc drop in such a tube is about 15 volts.

steady-state signals by causing them to modulate a carrier frequency which is later demodulated in the last stages of the amplifier. Carrier-type *systems* may achieve the same result by exciting the primary element with alternating current, causing this element to modulate the exciting current, then amplifying this gage output. The amplified signal may be rectified and filtered before being recorded, or it may be recorded directly as a modulated envelope. In this description there is no need to distinguish between systems which perform the modulation within the amplifier and systems which modulate in the primary element.

There are some other types of amplifiers—the carbon amplifier still used in some hearing aids (but probably nowhere else), mechanical amplifiers consisting usually of a relay-type mechanism synchronized by the incoming signal, and the magnetic amplifier of Alexanderson—essentially a saturable-core reactor which controlled large amounts of alternating current through the d-c. saturation of the iron core of a reactor. (Alexanderson developed this device to a high level of efficiency, but now it is used only in a few control devices and in voltage regulators.)

Amplifiers may be fitted with integrating and differentiating circuits, or with filter circuits which will allow transmission of only selected frequency ranges. These are most useful in vibration analysis; although 60-cycle rejection filters are occasionally used in static systems to reduce trouble from hum pick-up.

As a means of conserving the time of operators and computers, and of increasing the efficiency of operation with a limited amount of equipment, electrical computing devices are coming into use. Methods are available for making many different sorts of electrical computations, but the practical application of these methods is hardly begun. Devices of this sort usually employ amplifiers because of the greatly increased flexibility and convenience of operation they provide.

§2. Resistance-capacity Coupled Amplifiers.

By far the most common amplifying device is the resistance-capacitance coupled amplifier. It is put to many uses other than in measurement—telephone, radio receivers and transmitters, public address and intercommunication systems, etc.—and because of this wide and diverse application has been developed more than the other types. The development has taken place largely in tube design and in construction practice, however, since the demands for accuracy and stability imposed in the services listed are extremely low compared to the requirements for measuring amplifiers.

The ordinary commercial *R-C* coupled amplifier is not suitable for gaging applications except in special conditions; for example, as an uncalibrated null indicator or as an element in a carrier-type measuring system; and even then it often is necessary to introduce improvements in hum rejection and in response. But the stability, low cost and convenience in operation of this type of amplifier are such that many specially-designed and constructed units of this kind are in use.

A well-designed amplifier of this type is illustrated in Fig. 32. It is designed for operation from wire-type or carbon-type resistance strain gages, or from linear or torsional vibration pick-ups; it can also be used with other primary elements. It incorporates good design features such as push-pull operation throughout, calibrated step-attenuators, and stabilized supply voltages. It operates over a frequency range of 5 to 5,000 cycles per second and its output is sufficient to operate the customary forms of magnetic recording oscillographs. Four separate channels are placed on a deck (the illustration shows one deck). The output of any channel may be observed on the built-in cathode-ray oscilloscope. A practical convenience in operation is the back-illuminated input attenuator control, which makes adjustment easy and minimizes errors in setting dials. When a number of channels are in simultaneous operation, operating conveniences such as this are a decided help in minimizing operator fatigue and consequent error.

The amplifier in Fig. 32 is a general-purpose unit designed to provide stable and accurate amplification from any one of a number of different sources; the only real requirement placed on the input signal is that it be of suitable magnitude. Such an amplifier can be used for a large number of different applications, but it is necessary for the user to provide suitable input circuits. When the use for such an amplifier is limited to only a few kinds of measurement, it is more satisfactory to incorporate the required input circuits into the amplifier unit itself. In this manner the assembly is made more compact and more easily handled and installed.

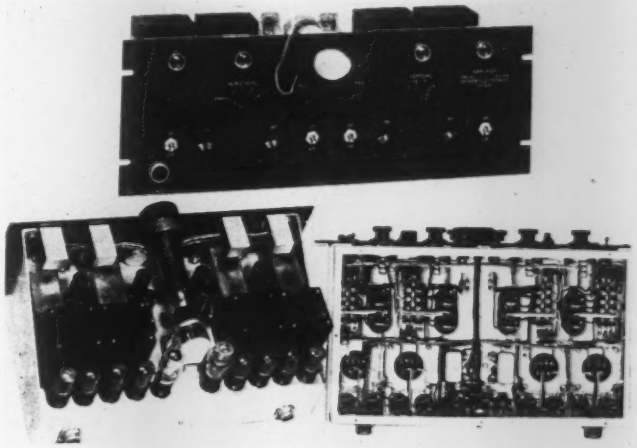


Fig. 32. General-purpose R-C Coupled Amplifier. *(Courtesy Offner Electronics, Inc.)*

There are other forms of resistance-capacitance coupled amplifiers which are especially adapted to certain applications; for example, there are amplifiers which operate entirely on a-c. power, applying alternating potentials to the electron tubes instead of the more common direct current (these amplifiers can be effectively used for steady-state measurements and for some control functions); there are current amplifiers, which do not increase the potential available but do supply many times as much current as could be supplied by the un-amplified element; and there are other types as well.

The amplifiers illustrated in Figs. 33 and 35 are also usable as *R-C* coupled amplifiers, requiring only simple switching operations to alter the input and output circuits.

§3. Carrier-type Amplifiers.

One of the most effective methods of providing stable amplification of extremely low frequencies (or of steady potentials) is with the carrier-type system. This system utilizes an alternating potential as a carrier, modulates it (in terms of amplitude) by the signal to be amplified, amplifies this modulated alternating potential, then demodulates the amplified signal. The amplifier proper is therefore required to operate only over a restricted frequency range centered about the carrier frequency, and extending above and below this carrier frequency only so many cycles as are represented by the incoming signal. That is, if a 1000-cycle carrier frequency is employed, and signals at frequencies no higher than 100 cycles per second are measured, the amplifier is required to operate only at frequencies ranging from 900 to 1100 cycles per second.

Carrier-type systems may be constructed in several different ways: the modulation may be performed in the primary element or in its associated circuit, or it may be performed in the amplifier itself; the output may be recorded as a modulated envelope or demodulated before recording. If the modulation is performed within the amplifier itself, the net result is that the system has most of the characteristics of a direct-coupled amplifier. More often, however, the modulation is performed by the primary ele-

*Often called an "a-c." amplifier, or an "*R-C*" coupled amplifier.

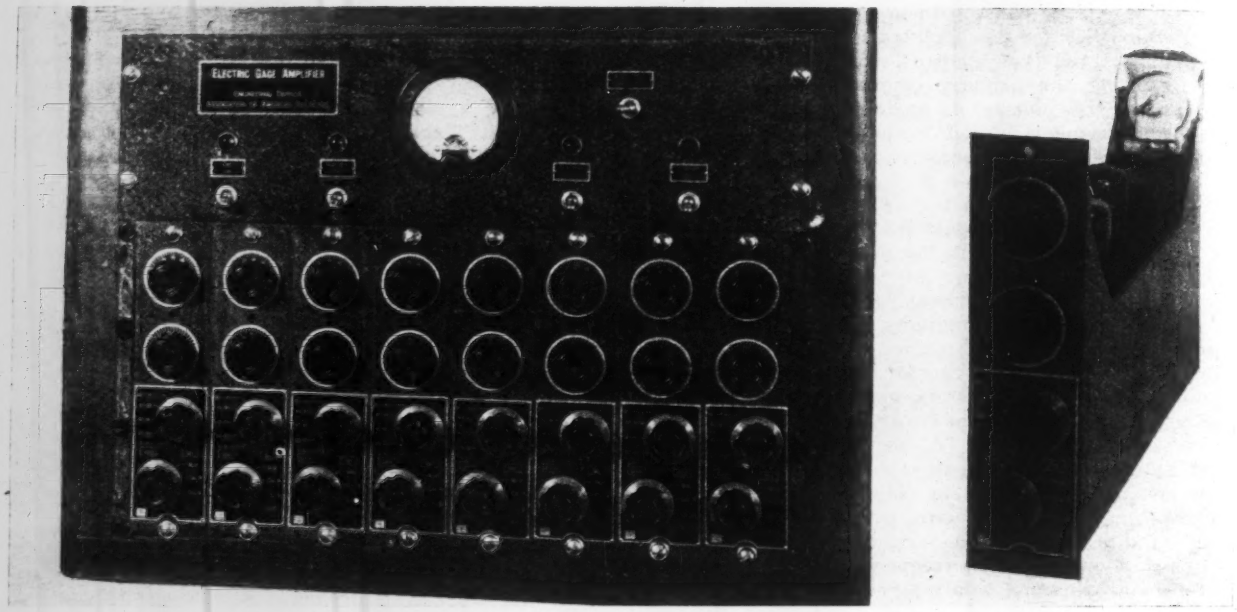


Fig. 33. Eight-channel Carrier-type Electric Gage Amplifier.

ment; an a-c.-excited bridge circuit with its unbalance potential applied to the amplifier input is commonly used.

The output is most conveniently recorded as a modulated envelope, but this practice involves a number of factors causing later inconvenience. The recording system must respond to the carrier frequency, which is relatively high. The optical efficiency of the recording system is made low by the fact that the available light from the galvanometer must be distributed over the entire modulated pattern instead of being concentrated in a single thin line. Interpretation of the records is less convenient.

If the demodulated output is recorded, interpretation is easier, but difficulties in circuit design appear when this is attempted. It is necessary, for example, to demodulate the carrier without distortion; and to filter out the carrier frequency so that the oscillograph trace will not be fuzzy, wide, and difficult to read. An even more serious problem is the establishment of polarity of the output of the amplifier.

Since the output of an a-c.-excited bridge circuit does not indicate the direction of unbalance immediately, as does the d-c. bridge, some means must be devised for making this distinction. The easiest method is to operate the system in an unbalanced manner, with the initial condition of adjustment incorporating an unbalance greater than any change anticipated in operation. Then, when the unbalance increases, the amplifier output will likewise increase, and conversely. This requires operation with some deflection always present on the indicating or recording instrument, which in many applications is quite inconvenient.

The most satisfactory mode of operation of a carrier-type amplifier is with a phase-discriminating output circuit, so arranged that unbalance of the input bridge circuit in one direction will cause the output current to show one polarity, while when the direction of unbalance of the input bridge circuit is reversed, the polarity of the output current is likewise reversed. (Some devices and circuits for accomplishing this result were illustrated and described in a previous installment.) A number of circuits of this sort are available, but most of them require great care in design and in construction.

An amplifier unit which incorporates most of the desirable features mentioned is illustrated in Fig. 33. This unit includes in a single case (14″ high, 20″ wide) eight complete amplifier channels, and all the necessary auxiliary circuits, including power supplies for all amplifiers and exciting current for the input bridge circuits. In operation all that is required is a source of 110-volt 60-cycle power. The amplifiers are designed for use with wire-type resistance strain gages, and can also be used with low-level magnetic gages—for which service they have a great excess of gain. The gain and power output is sufficient to provide a current output (into a 16-ohm magnetic galvanometer) of about 100 milliamperes in either direction from zero; a phase-discriminating output circuit is used so that tension and compression produce opposite directions of deflection. The carrier frequency is 3000 cycles per second, but can be adjusted from 2000 to 5000. Both resistance and reactance balance adjustments are available, so that the equipment can be used with cables several hundred feet long if necessary.

Since the heart of a carrier-type system is a resistance-capacitance coupled amplifier, the amplifiers in Fig. 33 are so arranged that by turning a switch they are converted into resistance-capacitance coupled amplifiers covering a frequency range from 10 to 8000 cycles per second.

To facilitate operation of this equipment under field conditions, practical operating conveniences were provided. The power supplies in the upper deck (which include two d-c. power supplies each with an output of 200 milliamperes at 360 volts, and a carrier oscillator which provides 35 watts of audiofrequency power) are all fully regulated so that changes in supply voltage or frequency do not cause any change in operation of the amplifiers. Calibrated gain controls are provided, as well as a calibration-checking circuit which affords checks of each amplifier's sensitivity at five points within its operating range. Calibration-check deflections may be placed on any record at any time during operation, without disturbing the operation. Each amplifier channel is separately constructed on its own chassis, and all are replaceable individually; a single separate channel is shown in the photo, at the right side of the complete unit. All connections are plug-and-receptacle; inserting an amplifier into the cabinet automatically connects it to the power supplies; the cables to the primary element and to the recording device are plugged into receptacles at the back of each amplifier.

Such a system as this is as flexible in operation as that of Fig. 32, and more conveniently used in its special fields. Its cost and complexity are much greater.

In the operation of a carrier-type system, serious difficulty often arises when long cables are needed to connect the primary elements to the amplifier. Both resistance and reactance balances must be provided if accuracy is to be attained, and accurate capacitance balance of long multiconductor cables is not always easy. The difficulty grows more serious as the exciting frequency is made higher, but in order to operate at high strain frequencies it is necessary to employ high carrier frequencies. In an attempt

eliminate this difficulty, systems have been developed in which d-c. excitation is applied to the bridge circuit containing the primary element, then the modulation is performed in the first stages of the amplifier. The same final result is obtained but, since it is not necessary to carry high audio frequencies over long cables, there is less difficulty with reactance balance of the system. But there is more difficulty in design and construction of the equipment.

It should be noted that in the amplifying system pictured in Fig. 33 the power supply is contained in the same cabinet as are the amplifiers. This is a convenience in operation, but unless care is taken in design it is a fertile source of hum and other disturbances in the amplifiers.

§4. Direct-coupled Amplifiers.

Direct-coupled amplifiers are employed when it is desired to record steady-state conditions and extremely low frequencies, and when for some reason carrier-type systems are not desirable. They have a further advantage that they can be made to respond to very high frequencies at the same time, whereas carrier amplifiers are limited in their upper frequency ranges to about 20% of the carrier frequency.

The design and construction of amplifiers of this kind is made difficult by the fact that nearly all of the sources of random error (changes in cathode emission, minor circuit noise, etc.) in resistance-capacity coupled amplifiers become major sources of drift and instability when the same components are used in direct-coupled amplifiers. The use of

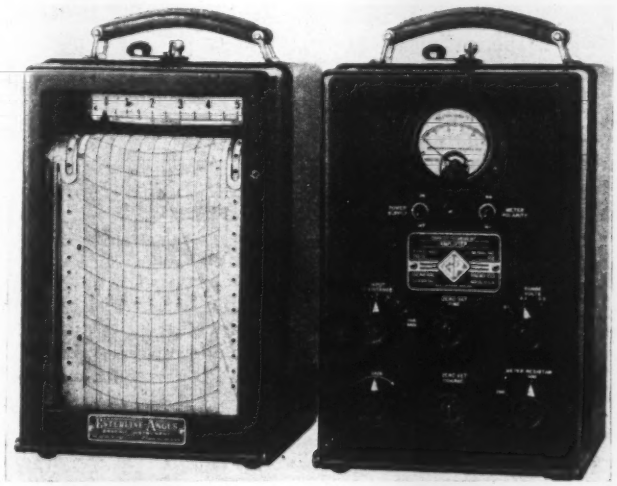


Fig. 34. Direct-coupled Amplifier and Chart-type Recorder. *(Courtesy General Radio Company.)*

large amounts of negative feedback can make the operation of an R-C coupled amplifier almost immune to changes in tube characteristics and in operating voltages, but it is not easy to employ this method of stabilization in direct-coupled* amplifiers. Increasing the gain of the amplifier by increasing the number of stages is an effective method in an *R-C* amplifier, but in a direct-coupled amplifier the circuit instability increases rapidly as the number of stages is increased, so that the practical limit is quickly reached.

Another difficulty is that high current output requires the use of a number of output tubes in parallel, and imposes exorbitant demands upon the power supply, since the entire output current of the amplifier must pass through the tubes and must be supplied by the power supply. The efficiency of such circuits can never be high if they are required to work into a low-impedance load, such as a magnetic oscillograph galvanometer.

Direct-coupled amplifiers do have a place in measurement, however, which cannot well be filled by any other type. In addition to their ability to handle an extremely wide frequency range (from static conditions to many thousands of cycles per second) they are ideal for recording low-frequency variations of potential in high-impedance circuits, where the total voltage gain required is not high, and where the frequency range is so low that it can be handled by a recording millivoltmeter or milliammeter. An amplifier of this type, especially designed for the application, and sufficiently accurate and stable to utilize the excellent characteristics of the recording milliammeter, is shown in Fig. 34. There are also available cathode-ray oscillographs employing direct-coupled amplifiers; these have many advantages, especially when studying non-repetitive or extremely low-frequency phenomena.

§5. Special Amplifiers: Integrating, Differentiating.

It is possible to modify to almost any desired degree, the frequency response—and other characteristics—of an *R-C* coupled amplifier; and this facility is of value in the design of amplifiers for the study of vibrations or detonation characteristics, since tuned circuits may be introduced for the analysis of phenomena being recorded. It is possible also to incorporate in such amplifiers circuits which will respond to rate-of-change, or which will average the signal, thus providing the equivalent of differentiation and integration.

For the study of vibrations the integrating type amplifier is especially useful, since it is possible to employ a single primary element, sensitive to acceleration, and to employ a single integrating element to arrive at a measurement of velocity, or two integrating elements to arrive at displacement. It is possible also to employ a velocity-sensitive primary element and differentiate once to measure acceleration.

Differentiating circuits are extremely useful also in the study of explosion characteristics, detonation, or shock waves, because with their aid it is a simple matter to employ a pressure-sensitive element to record pressure against time, or to record change of pressure against time. For some measurements the change-of-pressure is a better criterion. In servo-systems, and in anti-hunt circuits, differentiating amplifiers are of considerable value; in many cases they make possible a convenient method of precise and reliable control.

Integrating and differentiating circuits may be effectively introduced into ordinary resistance-capacitance coupled amplifiers but, when they are used, more stages of amplification are ordinarily required. The more effective such a circuit, the greater loss it introduces into the circuit; so it has become almost standard practice always to add a stage of amplification when an integrating circuit is used.

In Fig. 35 a complete amplifying assembly is shown, incorporating both single and double integration when desired. The cabinet shown holds twelve separate channels, which may be any of three separate types; all are the same size and interchangeable. These may be wide-band *R-C* coupled amplifiers incorporating integrator circuits which may be switched into or out of the circuits as desired, or

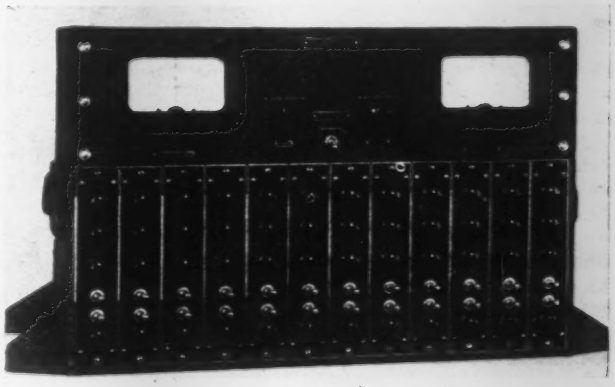


Fig. 35. Twelve-channel Electric Gage Amplifier with Integrating Circuits. *(Courtesy Hathaway Instrument Company.)*

*It should be noted that the abbreviation "d-c. amplifier" does not necessarily mean direct-coupled amplifier when it is encountered in the literature. It usually means a direct-current amplifier; carrier-type amplifiers will amplify d-c. levels.

carrier-type amplifiers, or double-integrator circuits. The double-integrator circuits are used always in conjunction with a carrier-type amplifier channel. This arrangement makes possible any one of three types of operation; (1) as *R-C* coupled amplifiers with a frequency response from 3 to 6000 cycles per second; (2) as carrier-type amplifiers employing a carrier frequency of 5000 cycles per second and effective from 0 to about 1000 cycles per second; or (3) with single or double integrating circuits and carrier-type amplifiers. All the integrating circuits are flat from 3 to 500 cycles per second. Indicating instruments are provided on the control panel by which either static indications or average values of vibration levels may be observed.

This assembly of amplifiers is capable of even more varied performance than the set shown in Fig. 33, but it is necessarily somewhat larger, since the unit shown in this illustration does not contain the power supplies (for which see Fig. 28), and the arrangement is such that it is necessary to interchange amplifier channels to provide the several different types of operation.

In all these units stabilized circuits are used, so that changes in line voltage or other factors does not cause any change in performance.

Units similar to these are available also in smaller, lighter form, battery-operated and intended for applications

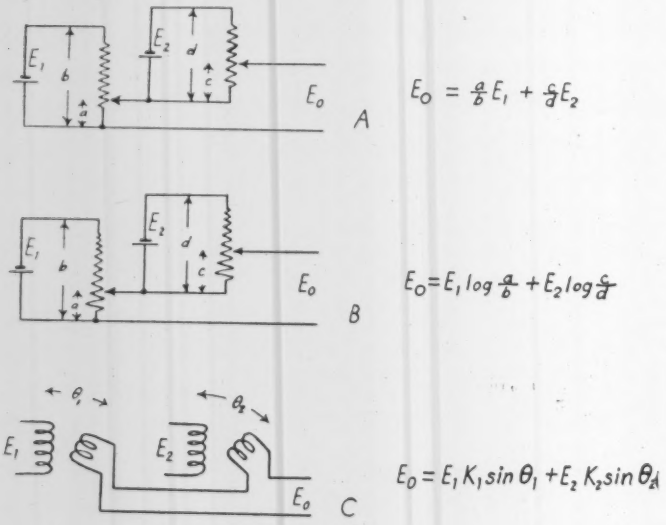


FIG 36

in which extreme compactness is required, as well as ability to operate under all conditions and away from line power.

§6. Computing Devices.

Electrical computation (by electrical circuits designed to perform mathematical operations, *not* simply computation by electric-powered calculating machines) is becoming an important element in the methods of stress and vibration analysis.

The integrating and differentiating circuits just described are special forms of computing circuits, and there are many others as well. These range from the complex and elaborate harmonic analyzers, employing numerous electric circuits and mechanical linkages all coördinated by servo-systems, down to the simple resistance-measuring instruments, which compute the resistance of a circuit component by passing a current through it and indicating the result on an instrument which is sensitive to the ratio of a potential and a current. A very large book would be required to describe and discuss all these methods.

Representative operating principles for the fundamental mathematical operations may well be listed here, although obviously there can be no detailed discussion of their operation in the available space.

Addition (or subtraction) may be accomplished by cascaded voltage dividers, and the sum indicated on a voltmeter; see Fig. 36A.

Fig. 37. Vector Computing Device. *(Courtesy Consolidated Engineering Corporation.)*

Multiplication (or division) may be accomplished by means of cascaded logarithmic potential dividers, which convert dial settings to logarithmic quantities and add these;* then the output potential may be reconverted to arithmetic values by a voltmeter having logarithmic response; see Fig. 36B.

Conversion of arithmetic values to trigonometric values may be accomplished by means of rotatable transformers, in which the output is proportional to the input potential and to the sine (or cosine) of the angle of rotation of the movable secondary; then the outputs of the several units may be combined; see Fig. 36C.

As many separate circuits must be provided as there are terms to be handled in the computation.

Extension of these basic methods (and others) to produce any desired computing device is a matter for the ingenuity of the designer.

One very satisfactory device, employing the principles mentioned and used for computing the effective magnitude and direction of strain from data taken by three differently-oriented strain-gages, is illustrated in Fig. 37. This instrument in a few seconds performs a computation involving three trigonometrical terms as well as several other factors.

XVIII. COMPLETE GAGING SYSTEMS

The purpose of this concluding chapter is to describe complete systems designed for making mechanical measure-

*This operation is best understood if the device is thought of as an electrical slide rule.

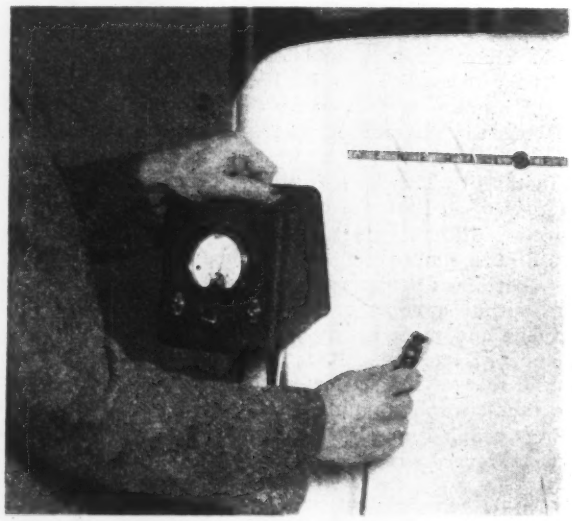


Fig. 38. Magnetic Gage for Enamel Thickness. *(Courtesy General Electric Co.)*

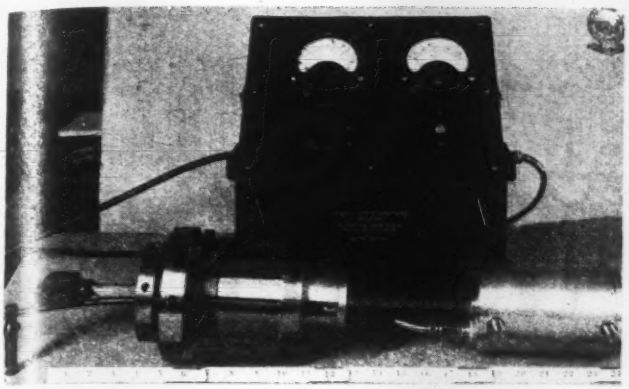


Fig. 39. Magnetic Gage for Gun-bore Straightness. *(Courtesy Baldwin Locomotive Works.)*

ments by electrical means. These systems are assembled from separate units of the types previously described; those illustrated here have been selected to demonstrate the manner in which separate units may be combined; and to illustrate some of the possibilities available through this method.

A complete gaging system comprises three distinct units: there must be a primary element or pick-up; there must be an associated control device or electric circuit—or an amplifier; and there must be some terminal instrument—an indicating instrument, a recording instrument or a controlled device. These three elements may occur in various electrical or mechanical combinations, or they may be entirely separated. But in all cases they—or their counterparts—must be present. A system is complete and self-contained (except for the primary source of power) when this is true.

A relatively simple self-contained measuring system is illustrated in Fig. 38; it is an electromagnetic device for measuring the thickness of non-magnetic materials such as paint coatings, bearing linings, etc., on steel surfaces. It employs the simple inductance-bridge circuit of Fig. 51, Part I; it is excited by 60-cycle current direct from the line; and it indicates its output on a pointer-type instrument. Only static indications are available. The measuring head is an iron-cored coil lacking an armature; the metal of the specimen becomes the armature when the pick-up is applied to the work, and the non-magnetic material provides the "air gap." It is effective only on non-magnetic materials backed by magnetic materials. (Measuring the thickness of the porcelain enamel surface of an electric refrigerator is the subject of the photograph.)

This gage may be compared to the Haskell Borestraightness Indicator, Fig. 39, which is employed to check the straightness of gun bores after heat-treatment and before final machining. In this instrument, a change in air gap is produced by any deviation from straightness of the steel surface as it is scanned by the guided pick-up head. The photograph shows the induction head, the guide-bar on which it rides, and one of the centering bushings for the end of the bore, as well as the case containing the other parts of the electric circuit and the indicating instruments.

Both of the instruments just described employ the work as a part of the magnetic circuit, and both are employed to survey a surface rather than to measure individual dimensions. Other types of instruments contain all portions of the magnetic circuit within the body of the device, and convey the motion to the primary element through a spindle.

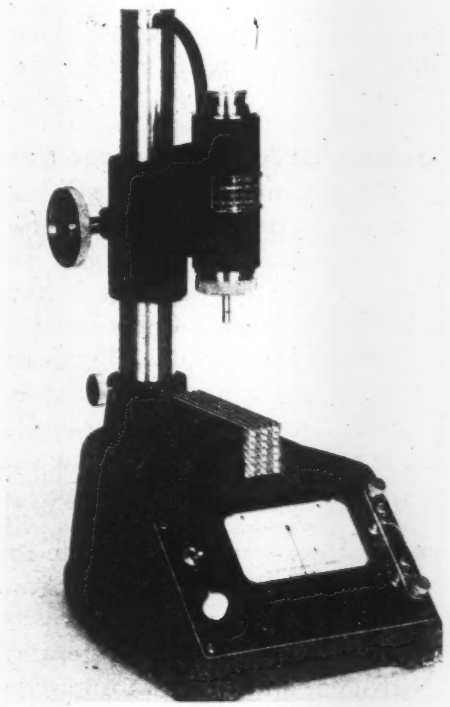


Fig. 40. Magnetic Comparator Gage. *(Courtesy Metron Instrument Co.)*

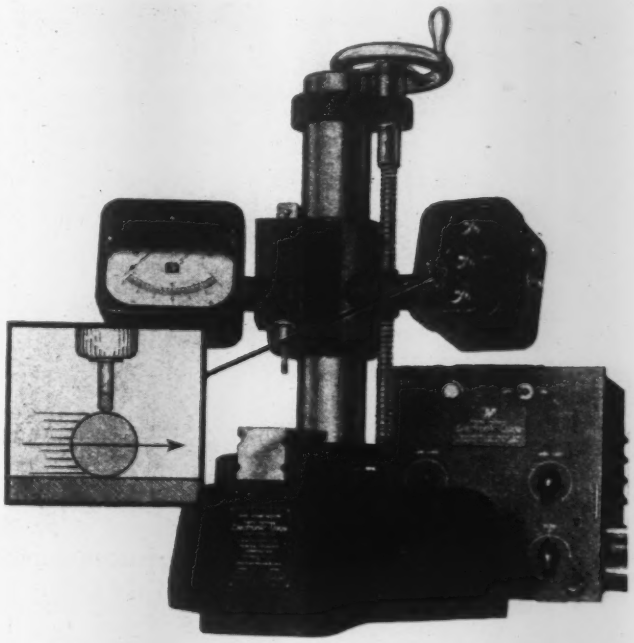


Fig. 41. Magnetic Comparator Gage. *(Courtesy Federal Products Corp.)*

The comparator gage illustrated in Fig. 40 is such an instrument. The entire magnetic circuit is enclosed within a housing, and the motion of the comparator spindle is applied to a movable armature in the primary element. This is a relatively simple instrument, but extremely flexible in application. The gage head may be moved to any desired position, so that pieces of different forms may easily be inspected. Since the device is a comparator gage, it indicates differences in dimension from a standard. Each instrument possesses four ranges or scales of magnification, the greatest being twenty times that of the lowest. Models are available having magnifications as high as 100,000 or as low as 100; for these instruments the value of one scale division represents one microinch and one thousandth of an inch respectively. For convenience in operation, a fine adjustment for zero setting is provided on the panel and a guard is placed over the scale-setting switches.

A somewhat more elaborate instrument of the same type is shown in Fig. 41. This also is a comparator gage, but in addition to indicating differences from the standard, it includes lights which signal instantly whether the piece being inspected is within limits, or if it is oversize or under-

continued on page 912

How to use the

ATOMIC

WHETHER atomic energy is just around the corner or only a dream, one thing is certain: You can benefit from the atomic bomb project right away! New engineering principles, new processing methods, new equipment—mere by-products of the atomic bomb—have already, by a conservative estimate, more than given back America its total investment in atomic research. Some of these benefits soon will be available to American Industry. For instance:

The Medical Profession is promised a new, more abundant and more useful source of radioactivity; extension of cancer therapy; and improved methods of combating toxicity in industry.

All Industry will be offered new types of pumps, and new methods of pumping; new, more efficient heat exchangers; new high vacuum techniques; new treatment of metal surfaces to prevent corrosion; safer and more economical production and use of corrosive chemicals and gases; and greater safety in refrigeration equipment.

The Gaseous Diffusion Process for the separation of U-235 from Uranium at Oak Ridge, for which Taylor is prime contractor for process control instruments, is the largest continuous process ever dreamed of. This is the process engineered by the Kellex Corporation and operated by Carbide and Carbon Chemicals Corporation. It employs a newly conceived barrier system so efficient and so economical in operation that it has been selected as one of the processes to be continued at Oak Ridge.

As a result, industry has available for the first time, *truly proven diffusion methods.* Some almost certain benefits will be: 1) Helium produced by this method rather than by refrigeration. 2) Oxygen, Nitrogen, and other rare gases produced without resorting to liquefaction and fraction

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distillation. 3) Direct isolation of Natural Gasoline fractions from crude petroleum instead of by fractionation.

More Precise Process Control Instruments. The gaseous diffusion process required the most gigantic, elaborate and precise system of process control ever conceived. Taylor was asked to assume the responsibilities of prime contractor for developing and producing or procuring the necessary control instruments. Because of the unprecedented processing tolerances involved, Taylor engineers had to develop from scratch many new types of instruments, and had to set up a mass production system to manufacture them in fabulous quantities. In addition, vast numbers of standard Taylor instruments were required.

Not many of the instrumentation details can yet be revealed. But the same men who worked them out for Oak Ridge—our research, design, production, and application engineers—are available to help you solve *your* processing problems! May we hear from you?

Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

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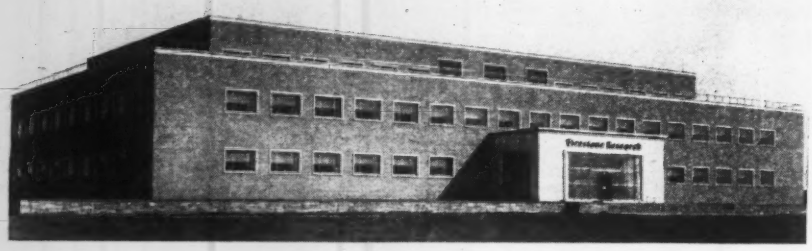


Sound-proof and air-conditioned, the new Firestone Research Laboratory is thoroughly equipped with instruments, some of them specially designed by Firestone scientists.

Instrumentation Made an Essential Part of Firestone's New $2,000,000 Research Laboratory

AKRON, O.—Tires that may wear as long as the automobile they are used on, that won't puncture, blow out or skid on wet and icy pavements are under development by rubber researchers and engineers, John W. Thomas, Chairman and directing head of The Firestone Tire and Rubber Co., said. These are but a few of the virtually unlimited possibilities for development which will be explored in Firestone's new $2,000,000 laboratory for rubber, plastics, metal and textile research.

Designed and constructed under the direction of Mr. Thomas, who rose from the company's first chemist to directing head of its worldwide operations, the three-story buff brick, air-conditioned building is located on a 20-acre plot high on a hill overlooking Firestone's plants. It has approximately 100,000 square feet of floor space and is equipped so that Firestone's researchers have at their instant command a vast array of the newest scientific instruments and apparatus.

The laboratory has prefabricated steel inner walls and partitions which can be moved to completely rearrange the interior of the building. Scientists work in two, four and six-man laboratories, but the larger laboratories can be revised if desired. A six-man laboratory, for example, could be divided into one four-man and one two-man laboratory, or into three two-man laboratories. The fixtures in the laboratories also can be rearranged to meet the varying needs of the researchers.

Service units provide facilities for hot, cold and distilled water, for steam, gas, vacuum, compressed air and a wide range of alternating and direct electrical currents.

Constant temperature and humidity control has been arranged for an infra-red room, an electrical measurements room and a physical testing room. There is a large library. An aging laboratory on the roof is used to check the effect of the weather on materials and products.

An electron microscope that magnifies up to 100,000 times compared with 2000 for an ordinary microscope is one of the important large instruments available to the scientists. An x-ray diffraction machine can be used in studying the crystalline structure of rubber and other materials. A quartz spectrograph and an infra-red spectrograph speed analyses.

One of the departments of the new laboratory is an experimental mill and curing room where rubber is compounded, mixed and vulcanized on a miniature scale.

Another innovation is a machine shop where Firestone research men build special scientific instruments they have designed.

Chemicals used in compounding rubber are ground and mixed in this ball mill at The Firestone Tire and Rubber Company research laboratory.

Two-, four- and six-man laboratories are found in The Firestone Tire and Rubber Company's new research building. The walls come in sections and can be arranged to any size desired. Shown here is a typical six-man laboratory.

Instruments developed by Firestone scientists* and installed in the laboratory include:

A forced vibrator for determining the properties of rubber in motion;

A plastometer for measuring the

*Some of these—and others not listed in this news item—were described in "What Instruments Do for the Rubber Industry" by G. P. Bosomworth, *Instruments*, Vol. 12, Jan. 1939, pages 36-38.

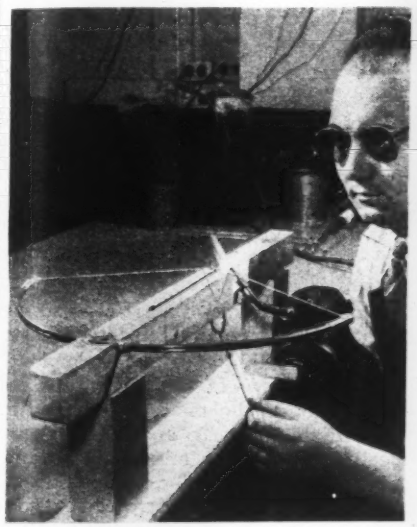
processibility of rubbers and rubber-like materials;

A relaxometer to study the effect of heat and oxygen on stretched rubber;

And a low temperature modulus test apparatus for determining the physical properties of materials at temperatures down to —100°F.

Cross-bow Plays Modern Scientific Role

EAST PITTSBURGH, Pa. — The cross-bow, storied weapon of medieval times, is being used by Westinghouse research engineers as a helpmate to a modern instrument, the electron microscope. Fashioned from tough, flexible steel and mounted on a wooden stock, the cross-bow shoots an arrow that draws out quartz filaments so fine it would take 60 of them to make the thickness of a human hair. The filaments—1/30,000th of an inch in diameter—are used to calibrate the magnifying power of the electron microscope.



To make such a very delicate thread, according to Dr. Alois Langer of the Westinghouse Research Laboratories, requires a high initial burst of speed that "spins out" the heated quartz while it is in a fluid state and before it has a chance to cool and harden. The cross-bow is about the simplest and most efficient instrument for doing this.

Since the electron microscope magnifies objects many thousands of times, its users need a very minute "measuring stick" by which to gage its magnification. A human hair, for example, seen under the microscope at its greatest magnification, would resemble a cable almost two feet thick.

Some of the filaments drawn by the bow are so delicate that they are invisible to the naked eye when viewed under direct light, Dr. Langer reported. In order to be seen they must be held at eye-level against a strong light. The light glances off the shiny filament, scattering its ray in different directions and making the filament appear much larger than it actually is.

When the Westinghouse engineer wants to replenish his supply of filaments, he places the cross-bow in firing position and attaches a small, cylindrical piece of quartz to the end of the arrow. Using a very hot flame from an oxy-hydrogen torch, he heats the quartz until it is just about to melt.

Then he pulls the trigger. The arrow darts from the bow at high speed, trailing behind it gossamer-like threads of quartz. Unbroken pieces up to 20 feet in length are not unusual, but more often the filaments are dispersed in smaller sections throughout the route the arrow takes. They are extremely flexible and can be wound round the finger like thread.

To measure the actual thickness of the filament, it is first put under the electron microscope and gaged by other methods of comparison. Once its diameter has been fixed accurately, it becomes a "measuring stick" for determining the magnification power of the electron microscope.

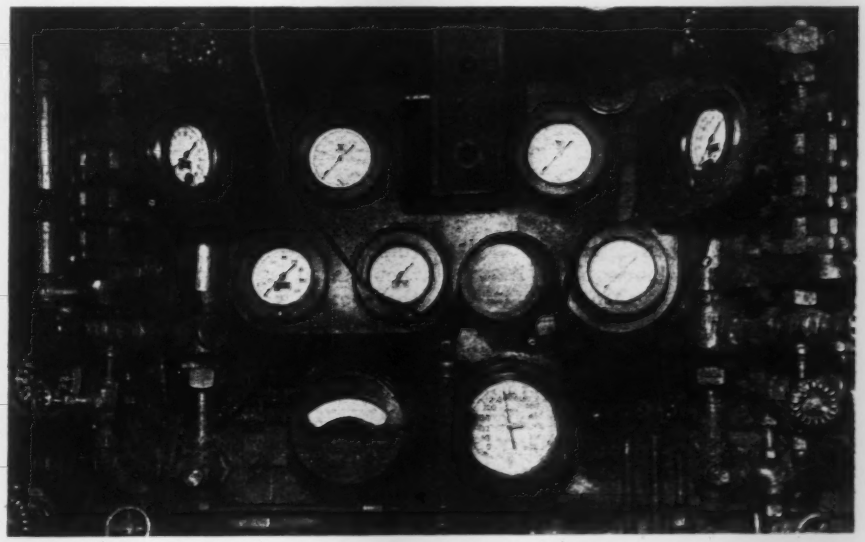


Fig. 1

Instrumentation of Geared-turbine Locomotive

EAST PITTSBURGH, Pa.—A geared turbine locomotive capable of producing 6900 shaft hp. has been developed by the Pennsylvania Railroad, the Westinghouse Electric Corp. and the Baldwin Locomotive Works. Higher efficiency and smoother propulsion are the most important of several advantages the unit offers over the conventional reciprocating drive. Since power is applied evenly through the gears, the unbalanced forces inherent in a reciprocating engine are eliminated. An increase of about 20% in efficiency not only means a savings in fuel but, more important, greater power output from a locomotive of given dimensions. Designed for fast, long-haul passenger and freight service, the locomotive can operate at speeds up to 100 m.p.h. Two

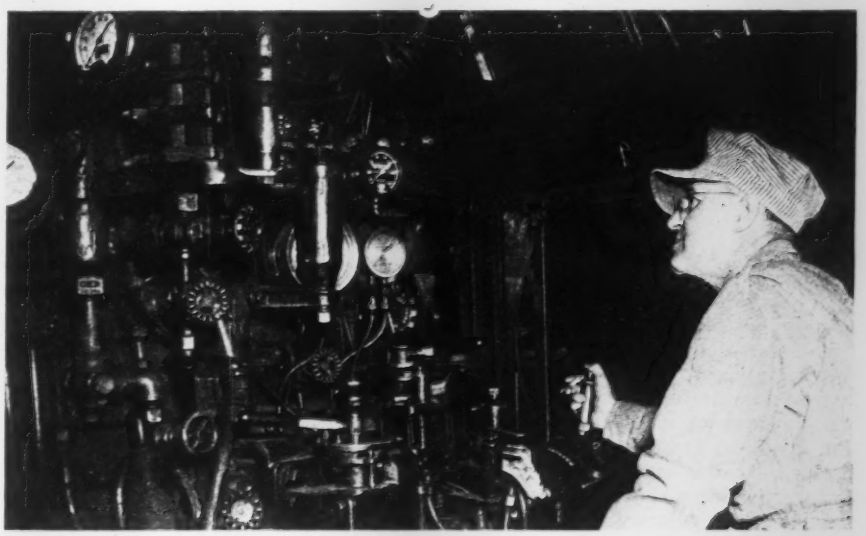


Fig. 2

turbines—one for forward motion and one for reverse—are connected through double helical reduction gears to the middle two of the four driving wheels. The forward unit, which is composed of six stages, is always engaged with the main gear pinion; the reversing unit, a single-stage Curtiss type, is connected only when the controls are in reverse. Steam at boiler outlet is 310 lbs./in.^{2} and 750°F., which is common for modern locomotives. Stoker-fired, the locomotive uses coal as fuel. The two photographs show its instrumentation. Fig. 1 shows the "instrument board," located between the engineer and fireman in the center of the cab; Fig. 2 is a continuation toward the right, showing the engineer's station. The control for the locomotive's forward and reverse motion is as simple as the gear shift in an automobile. When the lever on which the engineer has his right hand is in "low," the reversing clutch is engaged. "Neutral" is the off position, and "intermediate" allows steam to flow through the forward turbine. Should either turbine overspeed or the lubricating oil pressure fall below 5 lbs./in.^{2}, air in the relay-controlled pneumatic cylinders which supply air to the steam flow valves is exhausted to the atmosphere and the throttle valves close. In addition, a zero speed interlock prevents both turbines being engaged at the same time.

Ground Glass Surfaces Now Tested by Interference Method

ROCHESTER, N. Y.—A new and simple method of testing the accuracy of ground optical surfaces by means of optical test glasses has recently been adopted at the Bausch & Lomb Optical Co. It employs wax to fill up the matrix of furrows created by emery in the grinding process.

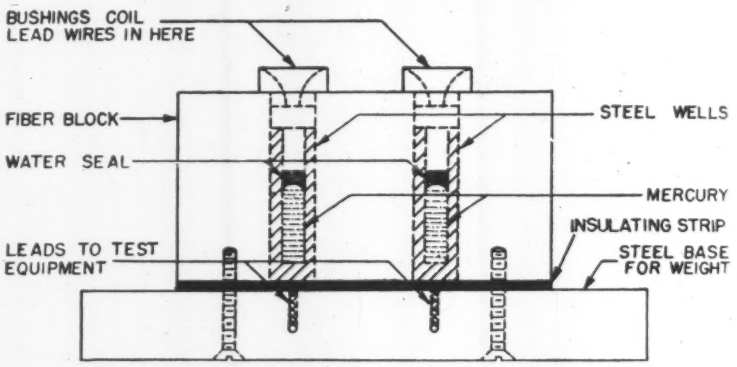
A ground surface is such a poor reflector of light that the usual method of examining polished surfaces by the light interference method is not practicable. When the rough surface is given a smooth coating of wax it becomes reflecting and its accuracy may be measured with a test glass having the proper curve or degree of planeness. This method is valuable in saving time and labor in the polishing process which follows grinding. The previous method of testing, by an optical spherometer, afforded less than one-tenth the accuracy attainable with test glasses.

The test glass, employed with monochromatic light, is the most accurate method known for discovering the nature and amount of surface irregularities. Utilizing light waves, test glasses disclose, by the arrangement of interference bands or rings, the nature and amount of irregularity in fractions of a millionth of an inch.

Mercury Contactor Speeds Coil Testing

SCHENECTADY, N. Y.—A mercury contacting device suggested by R. L. Bainbridge, a foreman at a General Electric plant, facilitates the testing of random-wound coils before they are assembled in small motors. With the equipment formerly used, it was necessary to heat the wire in a gas flame and wipe while warm with alcohol to remove the insulation. The wires were then placed on two copper contacts and the necessary electrical test made.

The new device originated by Mr. Bainbridge makes removing the insulation unnecessary. The ends of the wires are placed in mercury pools and contact is made through the bare cross-sectional area at the end. A small amount of mercury is placed in a steel well with an opening and bushing of about 1/16" diameter for the coil wires.

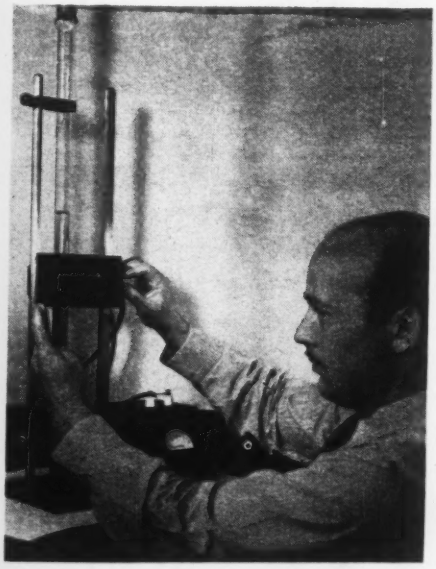


The steel well is connected to the test equipment. The level of the mercury is maintained below the bottom of the bushing, preventing it from spilling out of the well. A safety seal of ¼" of water is maintained on top of the mercury. It is seldom, if ever, necessary to clean or replace the mercury.

The mercury contactor has made the test more positive and safer and has cut testing time by 50%.

Photoelectric Method Speeds Analysis of Metal Particles for Powder-molding

EAST PITTSBURGH, Penna.—Using only a glass tube, a photocell, a light source and a milliammeter, P. R. Kalischer, Westinghouse research metallurgist, can determine grain sizes of metallic powders as small as 1/25,000 inch in about one-thirtieth the time usually required for such an analysis. Since the quality of a metal part produced by powder molding is dependent on the uniformity of the metal grains, this determination of particle-size distribution is especially important.

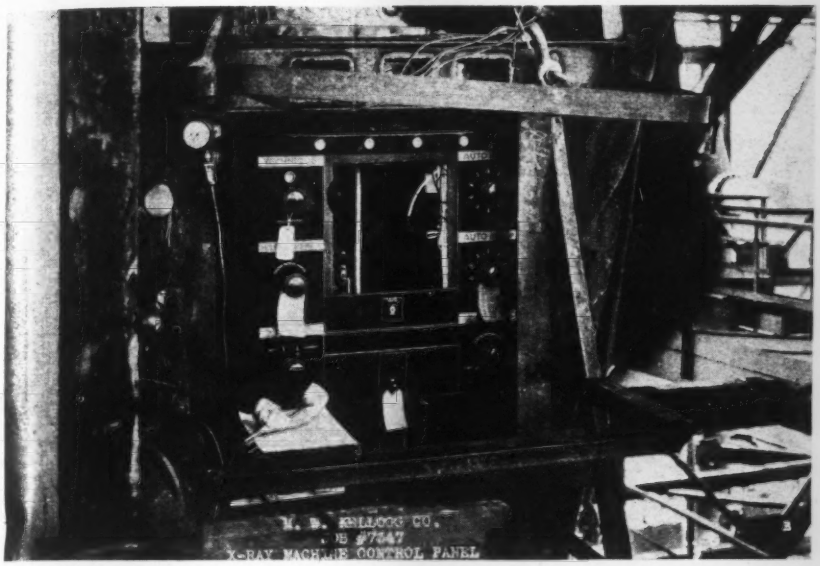


Photocell and light source are mounted on opposite side of the glass tube and the output of the photocell is read by the milliammeter. To analyze a powder specimen, Kalischer mixes one gram of it in the tube with 100 c.c. of acetone, to which a small amount of a wetting agent (isopropyl xanthate is one of the best) is added. The tube then is clamped between the photocell and light source. As the particles settle, the liquid clears and transmits more light to the cell.

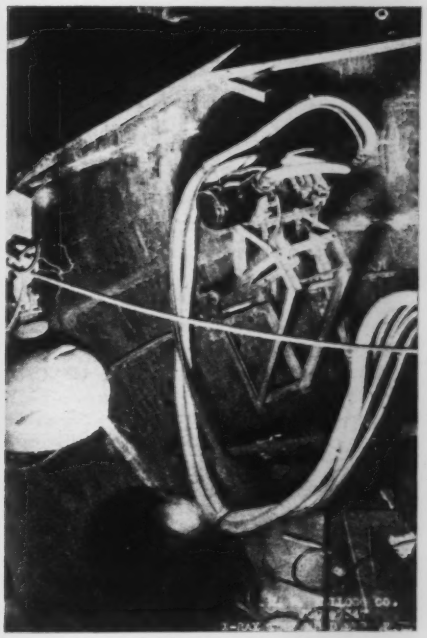
From timed readings of cell current a time-opacity curve is plotted for that specimen. By comparing this curve with similar curves for standard powders of known particle size, Kalischer can determine both average particle size and relative quantities of particles of different sizes in the test specimen.

The usual method of measuring particle size is to float the powder in glycerine and measure the settling time. Such a test requires about eight hours and does not give accurate information about relative quantities of grains of different sizes. The simplified Kalischer method takes only 15 minutes.

Use of a wetting agent is important, because it helps the acetone to surround each metal grain completely. Without it, the settling rate might be affected by tiny air bubbles surrounding the grains.



Control panel hanging at one of the "skyscraper" levels. When air hammer and other construction noises were too great, the doubly-insulated telephone was discarded in favor of colored signal lights for communication with operators at the tube head.



This photograph shows the x-ray tube head mounted 'way down inside the reactor for "shooting" the welds in the lower conical sections. Note the monorail carriage and track paralleling the weld seam.

X-ray Testing Helps Speed Construction of Huge Catalytic Unit

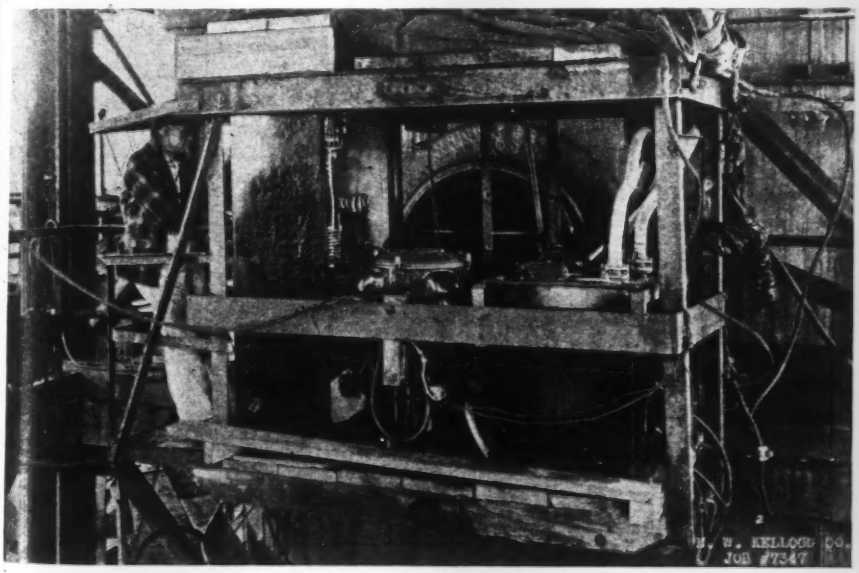
COVINGTON, Ky.—Engineering ingenuity and daring, demonstrated in the successful application of x-ray testing to steel welding at dizzy heights, is disclosed by the Kelley-Koett Mfg. Co. in describing an accomplishment that has provoked much favorable comment in construction circles.

As result of the successful use of x-ray testing, it was possible to complete the "Baltimore Giant," a fluid catalyst cracking unit at the Standard Oil Co. of New Jersey's refinery in Baltimore without welding defects.

Construction engineers of the M. W. Kellogg Co., general contractors and engineers for the "Baltimore Giant," were asked to x-ray all welds in the huge plant. This was the result of the Standard Oil management's desire to have a composite survey of the 250-ft. high "Giant"—a key unit in a $14,000,000 modernization program for production of high-octane aviation gasoline.

Technical experts of the Kelley-Koett Co. working with the Standard Oil Development Co. and the Kellogg organization "stripped down" a standard 220,000-volt x-ray unit made by the Covington concern. After fitting the unit to special rigging, the equipment was crane-hoisted from level to level.

Despite rainstorms and unavoidable jars and jolts, the x-ray testing of welds in awkward locations went forward successfully and is believed to be another indication for post-war x-ray applications in shipbuilding, plant construction and other heavy-industry uses.



X-ray machine set up ready for action. Transformers, etc., are stripped of protective covers to reduce weight. The only protection against the elements is tarpaulin shown rolled up atop the suspended crib.

Lamp Base Inspection Speeded Four-fold

BELLEVILLE, N. J.—A new inspection machine put into operation at the Westinghouse Lamp Division plant here speeds the inspection of metal lamp bases as much as 400%. Designed by Westinghouse engineers, the machine saves women inspectors the tedious task of picking up each lamp base to check it for possible flaws. Now the screw-type metal cylinders are turned over automatically as they jiggle down a sloping table which is vibrated by a motor underneath.

Inspectors used to sit beside a conveyor belt and as the metal lamp bases passed along, the women picked up each base to inspect both sides. This was tedious and time-consuming work.

In the new operation, the brass-plated iron bases are carried by a conveyor belt to the end of a sloping metal table where they are dumped. Each base rolls into one of eighteen parallel grooves which extend half the length of the table. The table's vibrating motion and downward slope causes the bases to move along while the operators inspect the top sides.

Then each base enters a short "turnover tube," consisting of several pieces of steel in spiral shape. The spiral turns each base upside-down so the inspectors can see the other side without picking up any but defective bases. At the lower end of the table, the bases fall off into barrels and are packed.

Electrical Control Instrumentation of Cal Tech Wind-tunnel

[SEE FRONT COVER]

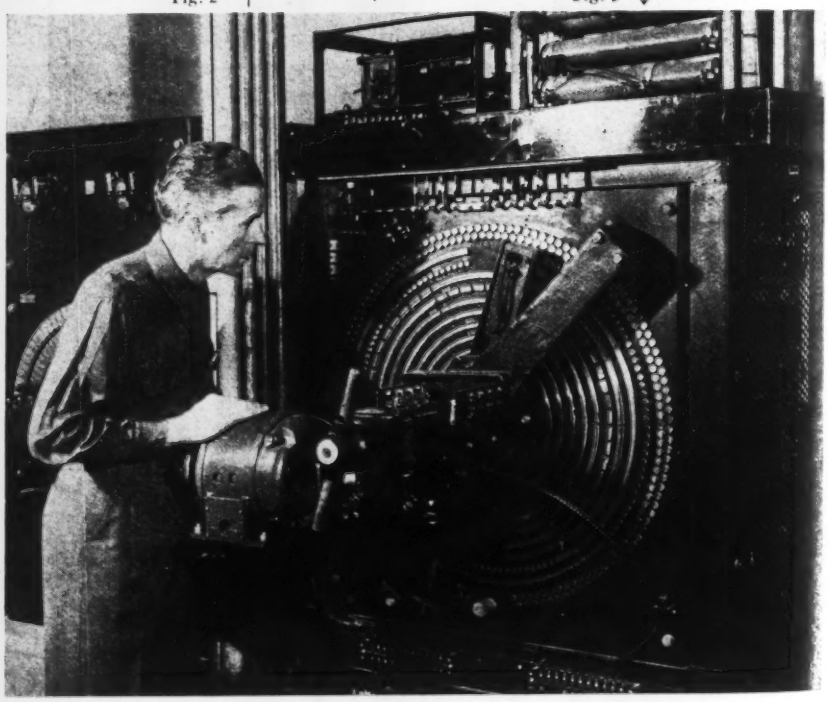
PITTSBURGH, Pa.—Unique among laboratories in which tomorrow's airplanes are being developed and today's improved and perfected is the Southern California Coöperative Wind Tunnel at Pasadena, Calif., operated by the California Institute of Technology and owned jointly by Consolidated Vultee Aircraft Corp., Douglas Aircraft Co., Inc., Lockheed Aircraft Corp. and North American Aviation, Inc. In the test section of the tunnel, model planes or components of full-size aircraft may be studied at pressures from one-fourth to four atmospheres, and at air velocities ranging from a gentle breeze to a super-hurricane of 700 m.p.h.—nearly the speed of sound. Working section of the tunnel may be hermetically sealed to enable model adjustment or modification without loss of pressure or vacuum in the rest of the tunnel.

Fig. 1 [cover photo—Ed.] shows the master control room from which all operations are directed and controlled and to which all scientific data are transmitted. The main control console, left and center, was manufactured by Westinghouse. Forces and movements acting on models under test are indicated on the large dials at the right and on light bank panels, center. Readings are recorded automatically on instruments in the foreground.

Many important control devices are mounted on the Westinghouse auxiliary control switchboard shown in Fig. 2. This photo shows George Karr, Jr., electrician, setting manually the desired power factor for the entire tunnel power system. This is done through a phase-shifting motor which sets the control point desired. Then the power factor regulator, shown in the glass-covered case directly above the power factor adjuster, maintains the set power factor. The power factor for all power, both 2300- and 440-volt, is maintained by adjusting the field excitation on a synchronous motor driving the main motor-generator set. The power factor regulator does this automatically by controlling a motor-operated field rheostat. At the top of the center panel above is an annunciator relay set-up. In the event of an automatic shutdown of the tunnel or any of its electrical equipment, this indicates the device which caused the shutdown, hence enables the operator to restore service promptly. Directly below the annunciator is a self-balancing temperature-recording instrument which automatically records the temperatures of various important pieces of electrical equipment in the tunnel. Directly to the right of the temperature recorder is a DT-5 electronic speed regulator which automatically maintains the speed of the main drive by control of the shunt field of the main direct current motor. At the bottom of the center panel section are overcurrent relays which automatically disconnect the main d-c. motor from its generator in the event the motor is overloaded. Also on this board are automatic current regulator circuits for the division of load between the a-c. and d-c. main drive motors. This regulator provides for the most economic division of load between the two units, so as to

Fig. 2 ↑

Fig. 3 ↓



maintain an overall economy of operation.

Fig. 3 shows the motor-operated gang rheostat for the wind tunnel. Walter Kinkele, foreman electrician, inspects a Westinghouse motor-operated gang rheostat. Remote-controlled from the console, this rheostat simultaneously controls the shunt field, the commutating field and the series field for both the main drive d-c. motor and the generator supplying power to that motor, hence controls the speed of the motor. An electronic speed regulator superposes a control on the shunt field of the

Fig. 4

main drive d-c. motor over and above the setting of the gang rheostat, if the speed should vary from its setting. Movement of the gang rheostat automatically changes the calibration of the electronic regulator so that it will maintain the speed set. Behind Mr. Kinkele can be seen a portion of the main motor-generator set synchronous motor field rheostat. This latter rheostat is under the automatic control of a power factor regulator on the auxiliary control switchboard. On top of the gang rheostat is a small motor which drives another rheostat controlling the differential field for the main generator supplying the main direct current motor drive. This rheostat, of the voltage-dividing type, enables the unit to go through a zero position and on to negative values and thereby brings down the residual voltage of the generator so as to maintain a zero voltage on the main drive d-c. motor to prevent creeping at standstill.

Power used to drive model planes under test in the new Coöperative Wind Tunnel is controlled through the Westinghouse-built switchboard shown in Fig. 4. Gene Boehme, electrician, is shown moving a control switch for a motor-operated rheostat. Such rheostats control frequency and voltage of variable-frequency motor-generator sets. Motor-operated rheostats provide two speeds, both slow and fast. They are equipped with indicating lights so that when nearing the end of their travel, indicating lights above each control switch show the operator their relative position. One control switch is used for fast movement and one for slow movement of each rheostat. This control switchboard is installed adjacent to the variable-frequency units in the tunnel power house.

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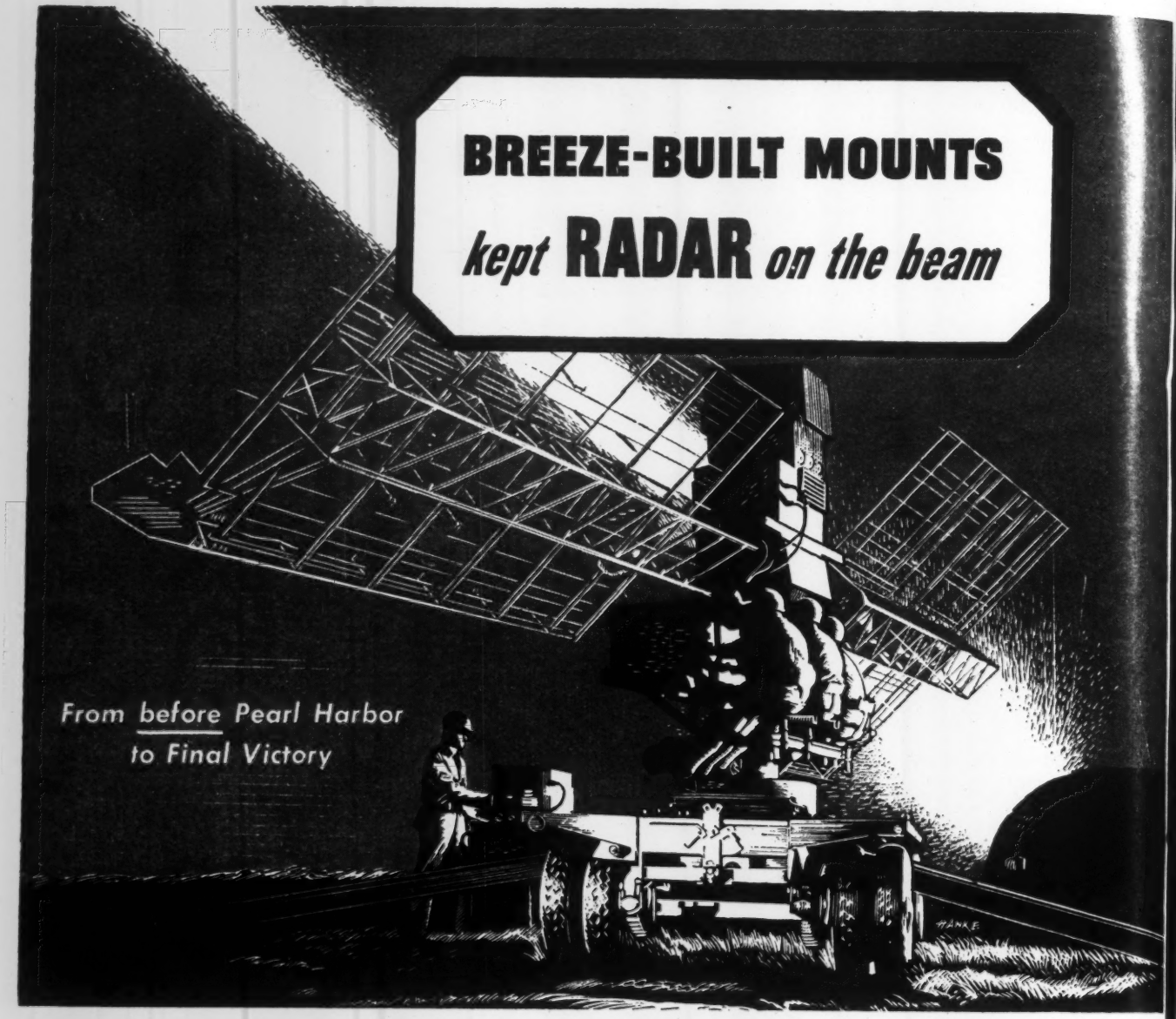

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Before Victory was won, thousands of Breeze-built Mounts were produced and delivered — in time and on time to every theatre of war. This production record, backed by product performance, offers further convincing evidence of the wide range of Breeze "know-how". Listed below are other Breeze products which have made the Breeze Mark the mark of dependability the world over. The diversified skills and facilities which enabled Breeze to build these precision items in huge quantities for war are now available to other manufacturers for peacetime production. Perhaps Breeze can solve that complex production problem for you. For a complete analysis and recommendation, call in a Breeze Engineer.

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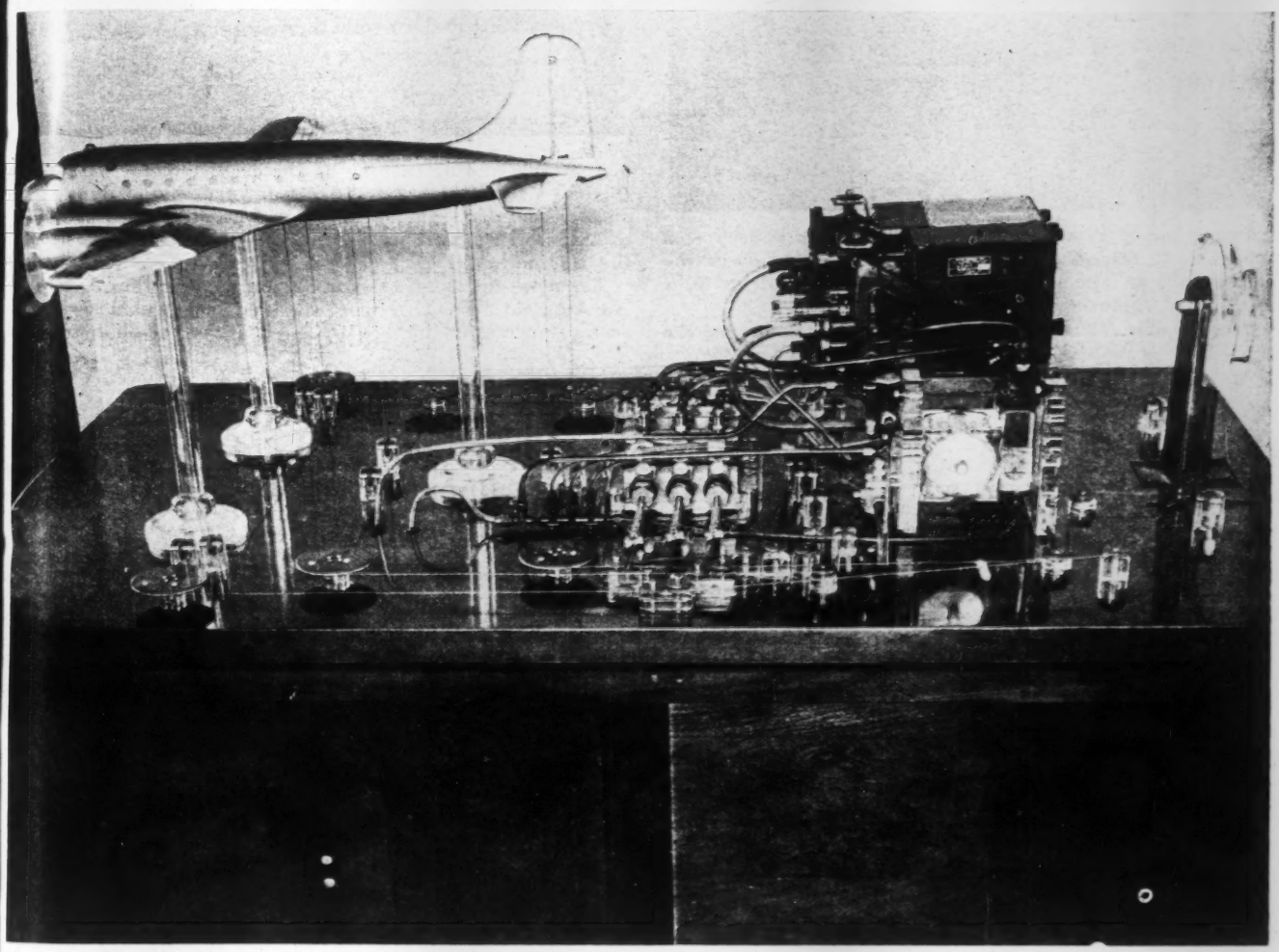
Aviation Instruments

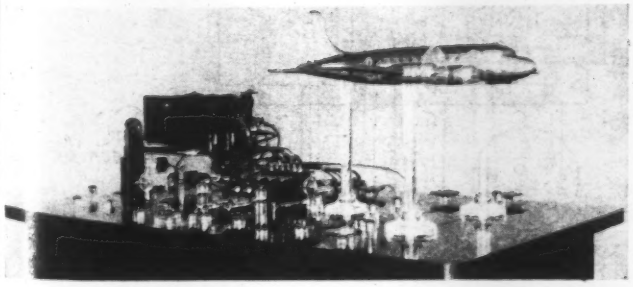
Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. IV, No. 12 M. F. Béhar, Editor December 1945



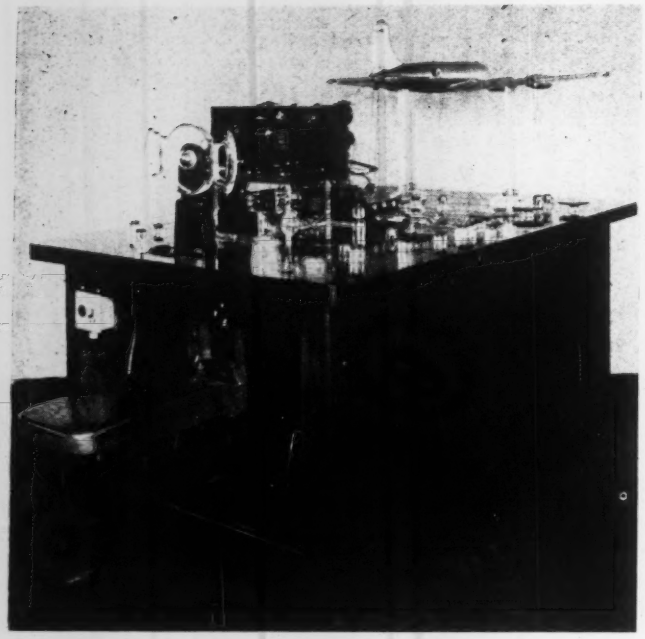
Transparent Mock-up for Automatic-pilot Instruction

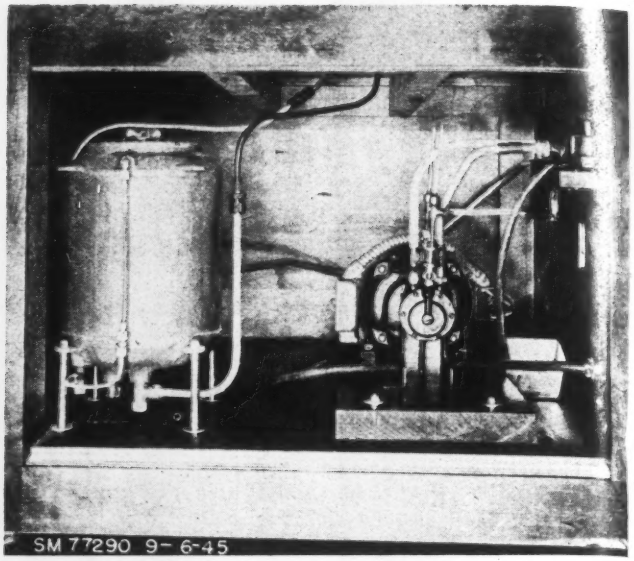
By N. F. McFADDAN, Los Angeles, Calif.



HEREWITH are some photographs taken at the Douglas Army Service School in Santa Monica, Calif., showing an automatic pilot mock-up, for teaching the A.T.C. Army boys the operation of the hydraulic type of automatic pilot.

The mock-up was built by the Douglas Research Department under the direction of the writer. The table is of birch wood, six by four feet. The plane has a metallic finish; and is mounted on Plexiglass rods above the table top; all fluid lines are of "Tenite" tubing; the components of the main hydraulic servo unit that operates the rudder, ailerons and





elevators are of Plexiglass. Red hydraulic fluid is used so it is possible to trace the flow through the system by observing the air bubbles. The air and fluid filters are also of the same transparent material.

It is possible for the student to sit on a saddle on one end of the table and by turning on the electric motor located in the base of the table, get the proper vacuum and fluid pressure on the dial gages in front of him, and then, by a set of standard rigged controls, proceed to bleed and check out the Automatic pilot.

The mock-up uses a standard Sperry A3 or Jack & Heintz A3 Automatic Pilot. A more detailed technical description seems unnecessary in view of the clarity of the photographs.

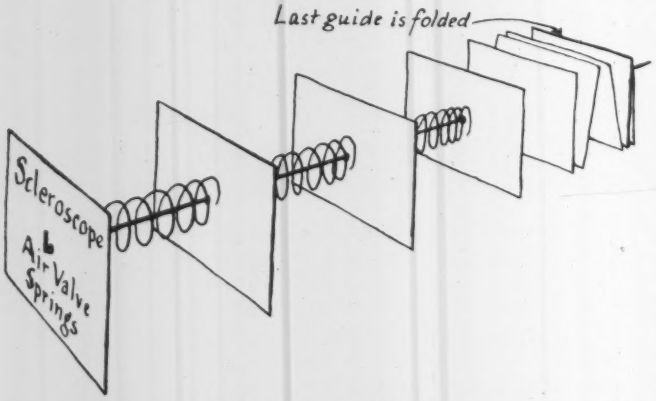
SHOP KINKS

Storing Instrument Springs

By GEORGE A. KAPLAFKA, Instrument Dep't Repairman, Thompson Aircraft Products, Cleveland, Ohio

IN the section of your magazine occasionally devoted to Shop Kinks I run across some helpful items. With this in mind I submit the following spring-storing idea. It may be as old as the hills but I've never seen it.

Tiny instrument springs generally become meshed together when stored in small boxes and in the separation process they require time and much patience to get them unmeshed

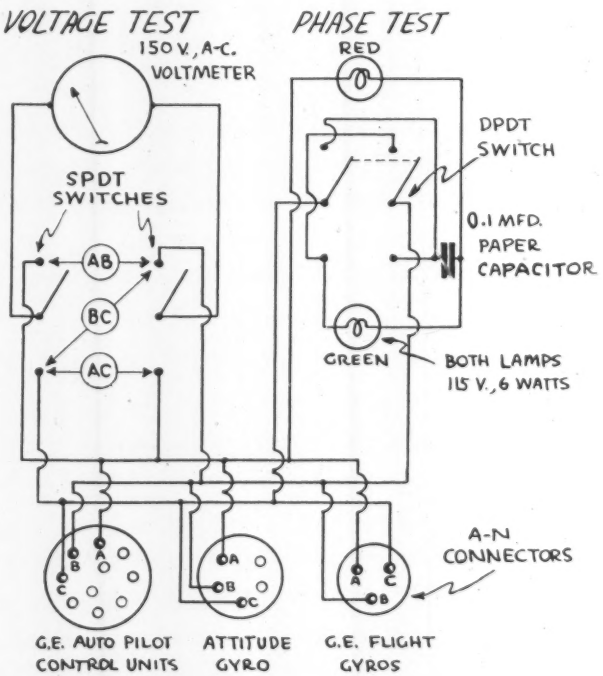


and unkinked. To make a "vertical file" for them, squares of cardboard anywhere from ½" to 2" square are cut out and a tiny hole is pierced in the center of each. (The 3 × 5 index cards found in most offices make a good stock to use.) Any stiff wire will do as a center rod to hold springs and cardboard in place. I used a No. 12 copper wire. For a clamp at the back, a small piece of cardboard is folded in half as shown and inserted last to hold the other guides in place. The front card is easily lettered to identify the springs stored.

Power Supply Tester for Electric Gyros

By M. J. WIGGINS, AMMI/1c, NATTC, Chicago, Ill.

THE present trend seems to be toward electrically-operated gyro instruments. Most of these units require 115-volt 400-cycle three-phase power supplies. This power is usually furnished by an inverter operating from the airplane's battery. During installation and trouble-shooting, it is necessary to check both the voltage across each phase



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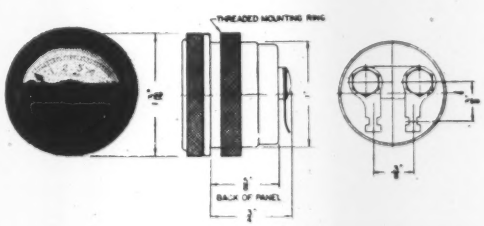

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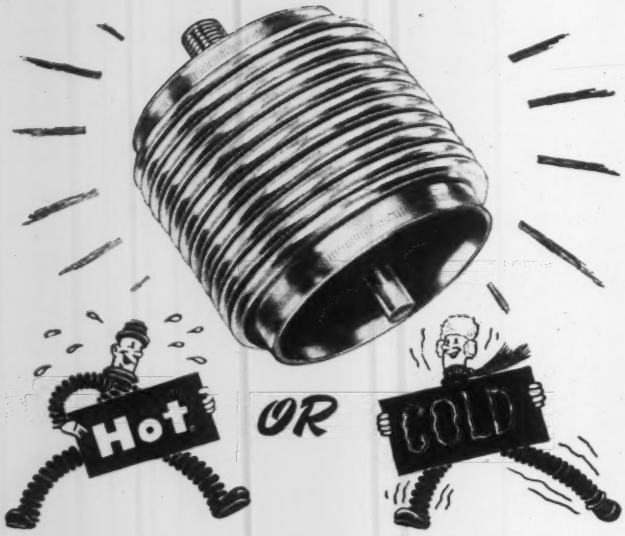

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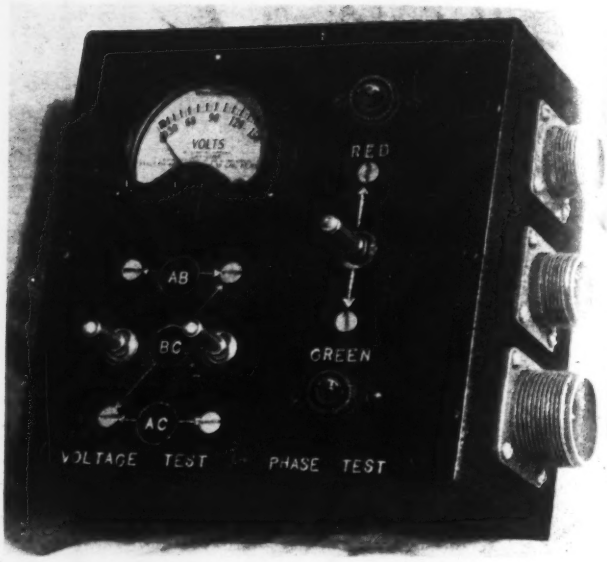

and the phase rotation of the inverter. If the phase rotation is reversed the gyro motors will run backwards, causing the various erecting mechanisms to operate in the wrong direction.

The unit described here was built to permit these tests to be made quickly and safely. Using a multimeter and test leads, or similar testing equipment, in back of a crowded instrument panel could cause shocks or shorts which might be dangerous at this voltage and frequency.

To test an installation, the Cannon plug is removed from the indicator and plugged into the corresponding connector on the test box. The inverter is turned on and the voltage output of each phase is read on the voltmeter. The voltage switches are thrown in the direction shown by the engraved arrows to read across the desired phase. The phase rotation is checked by throwing the switch to RED and then to GREEN. If the rotation is correct the red light will be brightest in the RED position and the green light will be brightest in the GREEN position. If the green light is

Cash for Shop Kinks

on instrument testing, repair, installing, etc.

This is to remind our readers that *Instruments* pays $5 (or more*) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication.

The following rules must be observed:

1. Type double-spaced on one side of paper. Author's name and address at top of first page (envelopes get lost!)
2. Diagrams must be in black ink (no blueprints). Lettering (if not made with aid of machine) may be soft-pencil, to be inked-in by *Instruments.*
3. Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).
4. Each contribution to describe ONE method or device. An author may send as many as he likes.
5. Mail all entries to Shop Kinks Dep't of *Instruments,* 1121 Wolfendale St., Pittsburgh 12, Pa.

*Five dollars is for textual entry accepted: a greater minimum is paid for accepted entries including drawings and photographs.

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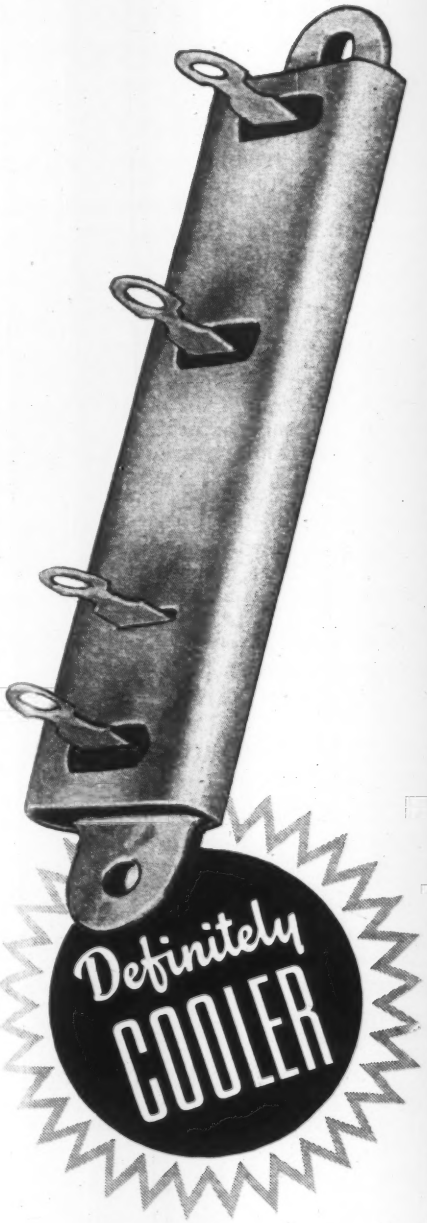

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brightest in the RED position the phase rotation is ...ckwards and should be corrected by reversing any two ...es in the inverter output cable.

The construction of the tester is apparent from the ...to and diagram. A rotary switch, if available, could be ...bstituted for the two toggle switches. However the sy...m shown works very well and the s-p.d-t. switches are usu...lly easier to get. The three connectors are wired in par...lel and will take care of the General Electric gyro hor...on and directional gyro, the G.E. Autopilot control units ...nd the Sperry Attitude Gyro indicator.

Soldering Aluminum Without Flu...

By T. E. JOHNSTON, San Diego, Calif.

IT is relatively easy to solder aluminum without flu... of any kind if the basic principle is understood. The r...ason it is difficult to solder to aluminum by ordinary meth...ls is because of the presence of an oxidized layer on the su...face of the aluminum. This oxidation takes place very rapidly on a freshly-scraped surface. However, if a puddle of solder is melted to cover the surface which it is desired to solder to and the aluminum scraped underneath the puddle, there is no chance for the surface to oxidize. Usually the scraping is done with the point of the soldering iron although other tools may be used for the purpose. This method will be found to give very good soldered joints. However, since the appearance may be deceptive, every joint should be tested for mechanical strength.

Calibrating 100″ Manometer

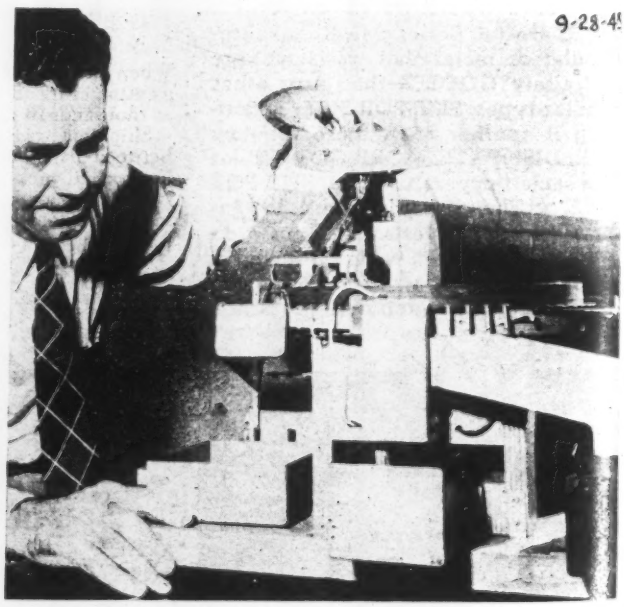
By J. C. G.

CALIBRATION of a 100″ orifice meter against a water column usually calls for a step-ladder or a periscope.

The men in the Instrument Shop of General Petroleum in Torrance, California, have really solved the problem. They have installed a well (pipe) through the bench and floor and suspended the manometer on a counterweight, guided it by two wires and use welding hose for flexible connections. Result, the reading can always be taken at eye-level. Nice going G.P.!

Rivet Anodyzing Improved and Speeded by Automatized Inspection

BALTIMORE, Md.—An automatic device developed by Walter H. Bankard, of The Glenn L. Martin Co., is attached to a standard rivet sorter [see *Instruments*, August 1944,



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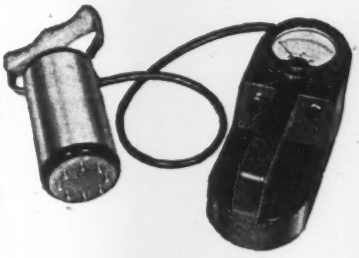

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Each button of the electrode is individually spring-cushioned to allow maintenance of contact regardless of contour — no points to break off or injure surface. It is completely portable, and can be operated by anyone.

The same exacting scientific research and precise engineering development that have made L-2 (lumber) and V-2 (veneer) models of Moisture Register the standard in their fields make the new model K-2 an accurate, dependable addition to this famous line. Write today for complete information, specifying type of material and per cent range of moisture content you wish to test.—Moisture Register Co., Dept. F, 133 North Garfield Avenue, Alhambra, California.

Direct reading dial shows moisture content of:
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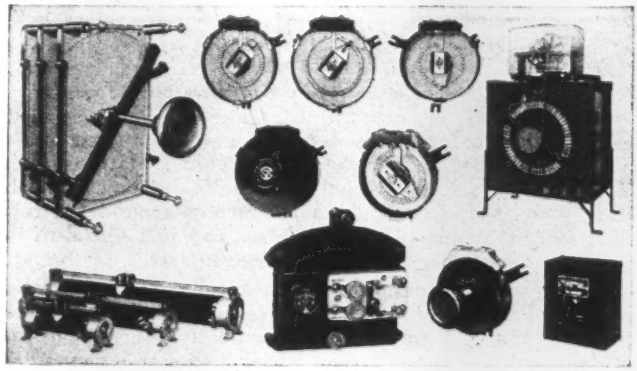

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WARD LEONARD ELECTRIC COMPANY
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This instrument is distinctive among clean-out U type manometers because of its *double* head—removable clean-out heads at both top and bottom. These heads are easily disconnected permitting quick and frequent cleaning of complete instrument.

The manometer (Model B-1275) has a large bore Pyrex tubing of 7/16" inside diameter which gives a flat indicating fluid meniscus. Bold numerals and graduations facilitate distant reading. Scale is adjustable.

B-1275 is designed for maximum line pressure of 100 lbs. per sq. in. It has holes for mounting to wall or panel. Ask for Catalog C-11 giving other features of this outstanding instrument.

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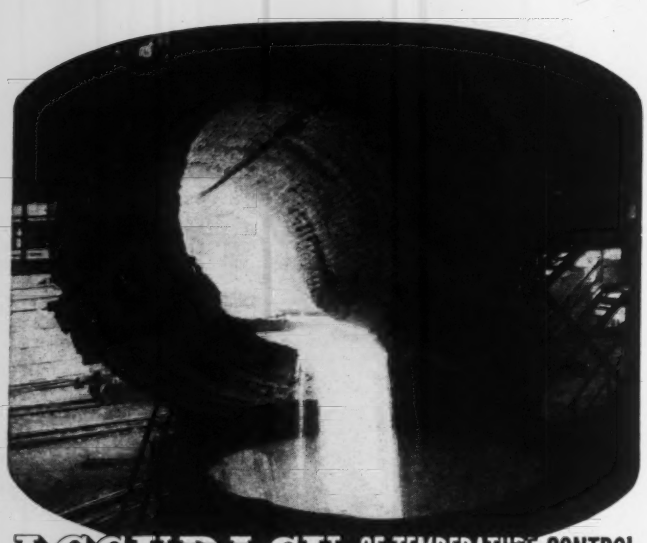

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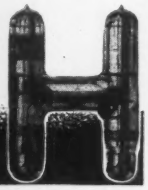

EPLAB Standard Cells For Potentiometric Instruments "As Standard as Sterling"

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MEAD SPECIALTIES COMPANY
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pages 466-467] and has been the means of improvi[ng] the methods of anodyzing rivets, so as to increase the o[ut]put and cut down on man-hours.

Mr. Bankard's development is a special electronic d[e]vice of low voltage, with a magnetically-operated lever wh[ich] is energized by completing an electric circuit between the [rivet] and the contact point. As the rivets pass through the [sepa]rator, the contact point touches the head of the rivet, a[nd] if the rivet does not come up to anodic specifications, a s[mall] relay is energized, and the relay throws out the rivet.

The electronic control was designed by Mr. Banka[rd] to meet a specific need. An Industrial Engineering Effec[tive]ness Report called attention to the need for improved m[eth]ods in anodyzing rivets. The Methods Group picked up this item from the report and made it the subject of study. Mr. Bankard was then assigned the task of developing [some]thing by which it would be possible to separate rivets ano-dyzed according to specifications, without having them s[or]ted by hand, as had hitherto been necessary. His device was developed and has proved highly efficient for the purpose for which it was intended. It is widely applicable in its use, being of value wherever anodyzed rivets are used.

SCIENTIFIC GLASS BLOWING

Continued from page 881

arm is allowed to rest against the tubing as shown in Fig. 21. The glass is then broken by pulling back and away with the arms exerting a perpendicular force to the tubing.

On a glass system where tubes are interlaced from one fixed object to another, one is limited to a minimum of pulling or tugging for fear of serious breakage. This fixed tube must be marked with the edge of the file, then wetted

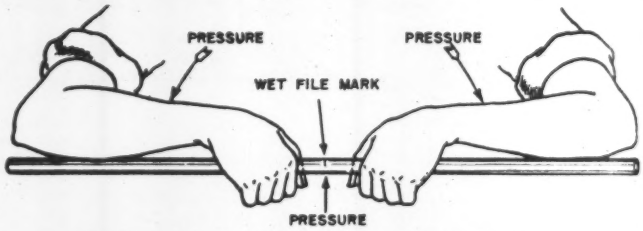

Fig. 21. Method of breaking tubing larger than 13 mm.

as described before. The point of a 5 mm. glass rod is heated white hot and touched to the center of the scratch. Generally a crack begins and encircles the glass completely. If it starts but does not run completely around the tube, then lead it by touching a hot glass rod just ahead of the crack in the proper direction until complete.

Tubing of larger diameter can be cut using the application of heat by means of a hot wire. Here the scratch must encircle the glass. A scratch made manually is often not concentric with the tube. A steel wheel with a thin sharp edge about 12" in diameter, mounted on a motor shaft, will make a perfect circle scratch when the glass tube or bulb is turned against it, provided a stop is employed at the end of the tube to prevent shifting.

An electrically heated hot wire system is illustrated in Fig. 22. A semi-loop of 26 S.W.G. nichrome wire is adjusted to the tubing diameter and arranged in series with a suitable resistance, which is encased as shown in Fig. 22, and connected to a 110 volt source. The resistance may be replaced by a variable transformer. The tubing is placed against the wire which coincides to the scratch. The current is switched on and the glass is held steady for a short length of time. On thin walled glass the crack will begin of its own accord, but on heavy walled glass it is started by touching a cold wet paper or cloth to the center of the heated portion. Once started, the crack is led by holding a new portion of the uncracked circle against the red hot wire. NEVER LEAVE A GAP between the part to be cracked and the crack already started. Soft glass should be rotated against the wire because it will crack completely around almost immediately.

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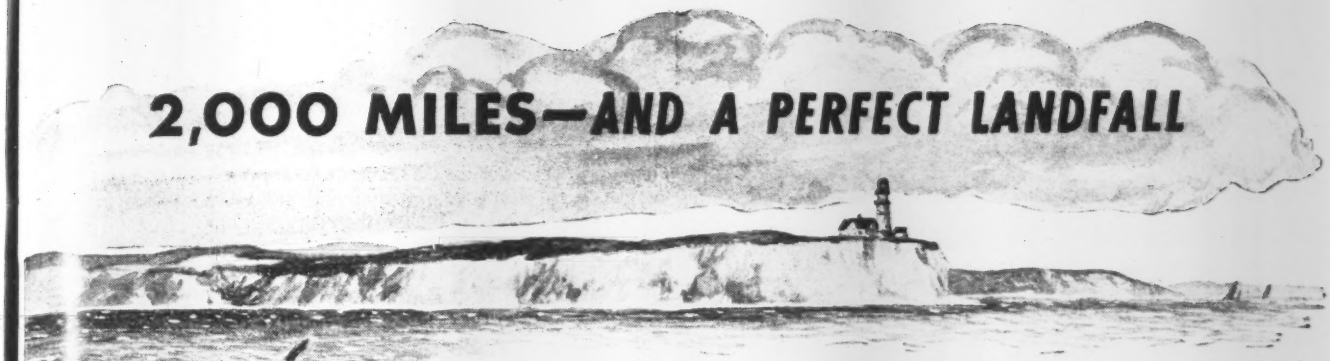

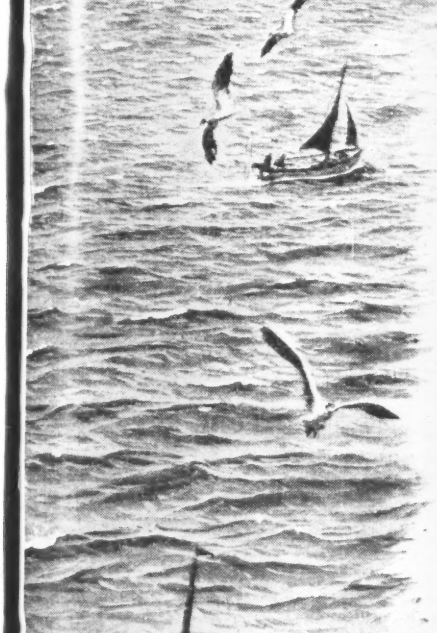

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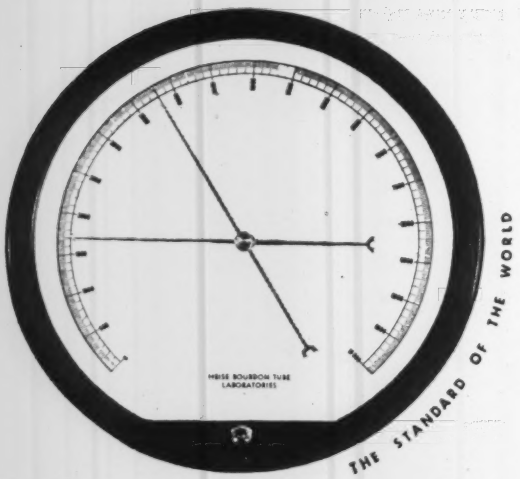

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A modern cutting machine is a requisite to the glass shop. A suitable cutter consists of a bonded abrasive wheel 2" in diameter and 0.04" thick which rotates with a stream of water played upon it from both sides, Fig. 23. Cuts of any angle desired can be made by a simple manipulation of a geared miter head located on the cutting table. True clean cuts can be made and in certain operations may save valuable time. A cut for example could be as small as 1/32". By proper holding or clamping, tubing ends can be sloped. Since glass is very brittle and tubing is usually burred slightly, care must be exercised to avoid a strain on a partially finished cut. The glass may be supported and held tight by the left hand and the right hand should lightly

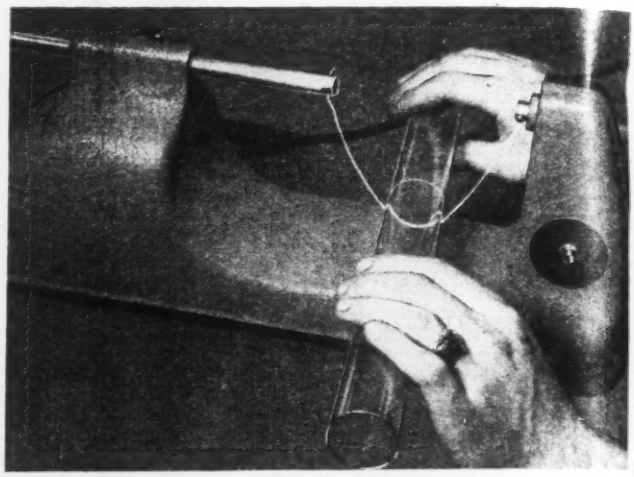


Fig. 22. Electrically heated hot wire system for breaking tubing of large diameter. (Photograph courtesy of Fisher Scientific Co.)

dampen vibration. At the completion of the cut, slower cutting will eliminate the possibility of burred edges. Observation will show a semi-polished edge, which if sealed to another tube, would leave a permanent gray line. This can partially be removed if fire polished before sealing together. If the end were reinforced by melting down a small portion of the tube and belled slightly, the cut mark would barely show. In the preparation of parts, long lengths of tubing can be cut to lengths a little longer than desired and these may be used in such a manner that their cut ends are removed in the flame.

The wheel is powered by a ½ horsepower motor at 1760

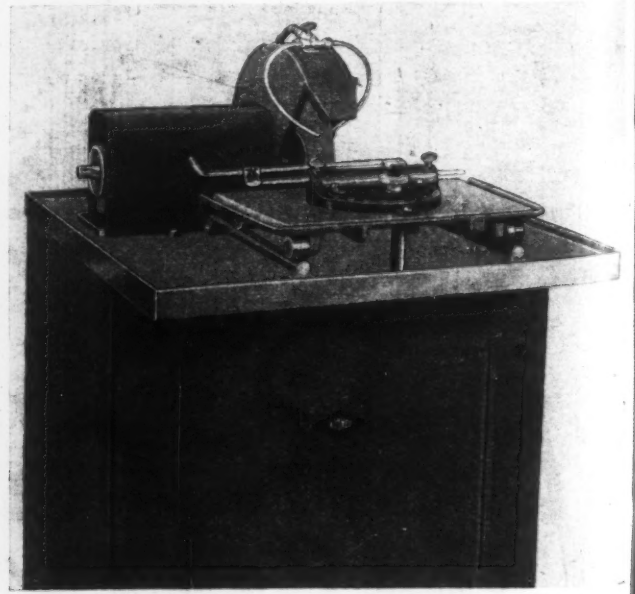
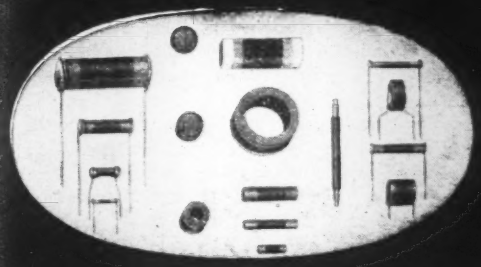
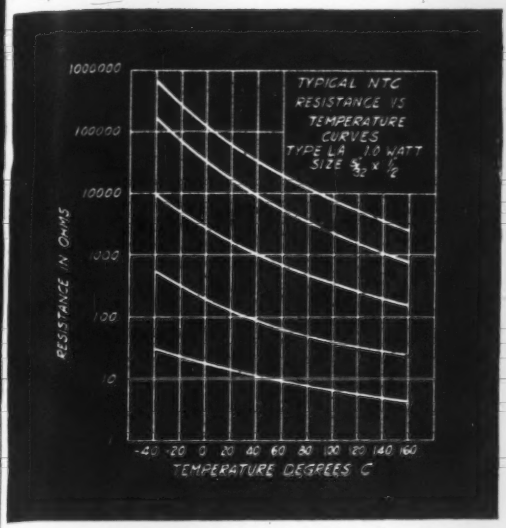


Fig. 23. Modern cutting machine. (Photograph courtesy of American Instrument Co.)



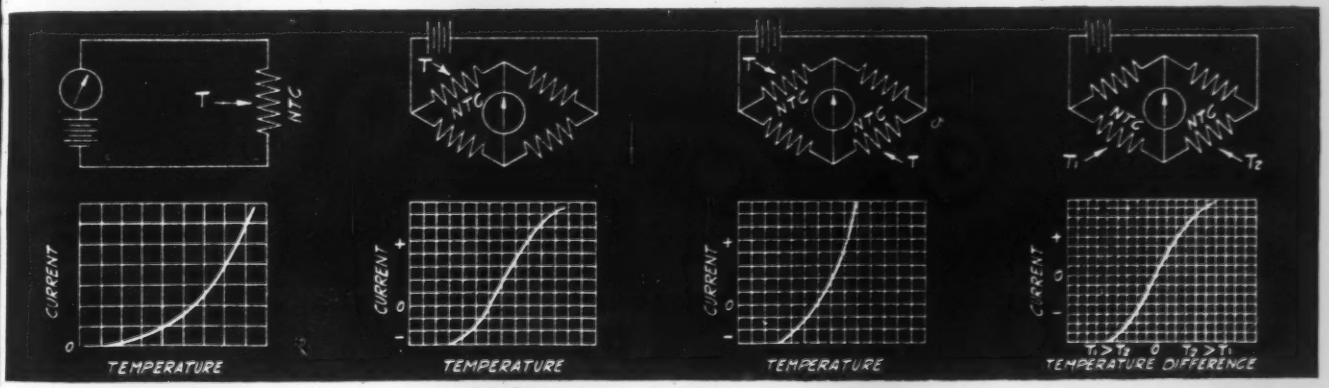
Do you have a

TEMPERATURE MEASUREMENT OR CONTROL PROBLEM?



CHECK THESE ADVANTAGES OF KEYSTONE NTC UNITS FOR YOUR APPLICATION

Keystone NTC units are electrical resistors especially developed to have an unusually high negative temperature coefficient of resistivity. The slopes are much greater than those observed with pure metals or their alloys. The result is an element with very high thermal sensitivity, useful on AC or DC, inherently suitable for remote indication, which has gained wide acceptance for temperature measurement and control purposes. NTC units are made in wide range of shapes, resistance values, temperature coefficients and wattage ratings, of which the characteristics at the left are typical. The circuits below suggest basic means for translating resistance changes into current or voltage variations. Modifications and extensions of these principles are many, especially in conjunction with electronic apparatus.



This simple series circuit of voltage source, instrument and NTC unit has been utilized to indicate engine coolant temperature, etc. It provides sufficient accuracy for many applications despite scale crowding at the bottom.

Basic bridge circuit straightens and steepens the characteristic. Zero-center meter may be used or balance point may be placed near the lowest temperature. Electronic balance indication provides enhanced sensitivity.

Adding a second NTC unit, and exposing both to the temperature to be indicated, gives a double unbalancing effect and increases sensitivity under certain conditions over part of the temperature range.

Two NTC units in adjacent arms is a method of indicating equality of two temperatures, or temperature difference or rise. Temperature of either source can be obtained by substitution of standard resistance for other NTC unit.

Keystone NTC resistors are also valuable for neutralizing the change in resistance with temperature of electrical indicating instruments and control devices, for introducing time delays and many other applications. Write and tell us about your problem—we'll be glad to analyze it for the applicability of NTC units.

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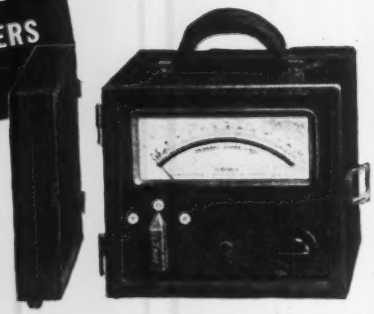

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Occasionally a cutting job is necessary on different types and sizes of large soft-glass containers. Instead of employing a scratch and hot wire system, the container is placed on a turntable which can be turned just fast enough that centrifugal force will not throw it off center. A small Hoke torch is clamped solidly in position and as the turntable is set in motion, an oxygen and gas flame is played

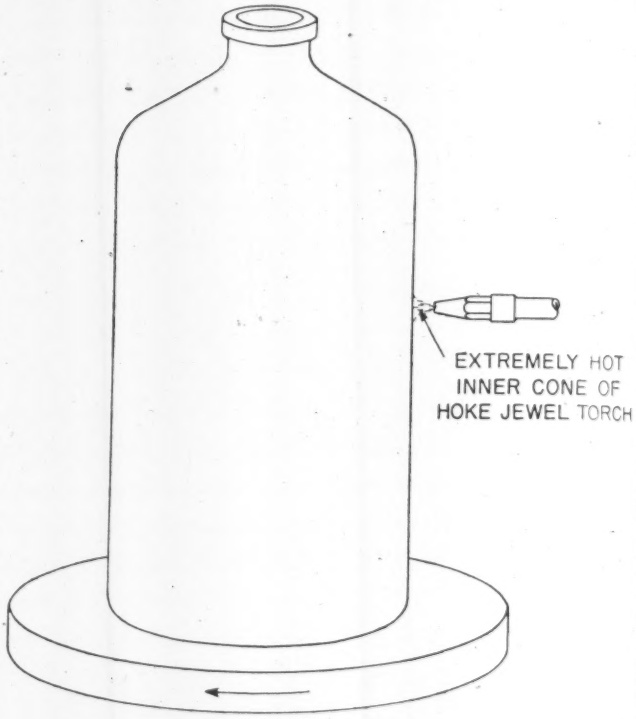

Fig. 24. Arrangement for cutting very large soft glass containers.

in a set position approximately one-quarter of an inch from the glass. After a number of revolutions, the glass vessel will crack cleanly and square. This end may then be ground on a flat plate with carborundum and water, but do not attempt to fire polish the edge. The arrangement of such a turntable is shown in Fig. 24. It should be pointed out that a procedure, as outlined here, depends upon the rapid heating of a narrow portion of the glass to cause fracture. The glass blower should remember this when he is working on a glass assembly with a hand torch. Unintentional movement of a hot flame across tube sections may cause immediate or subsequent breakage because of strains set up in the glass.

Glass and Glass Storage

A prime requisite in blowing glass is that all glass be clean. A sufficient supply should be stored in a dust-proof cupboard. Tubes should always be cleaned both inside and outside before they are used. Swabs for different tube sizes are easily prepared by using a piece of folded cheesecloth tied to a stout cord.

A small weight tied to the free end of the cord will aid in dropping it through the tube. The swab is then drawn through the tube. Cleaning solutions of sodium dichromate in sulphuric acid or solutions of commercial detergents are often required and should be prepared and stored in reagent bottles.

In the repair of broken equipment the glass blower should be sure that all surfaces are clean, especially those that must be fused in the blast burner.

(To be continued)

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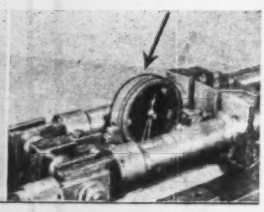

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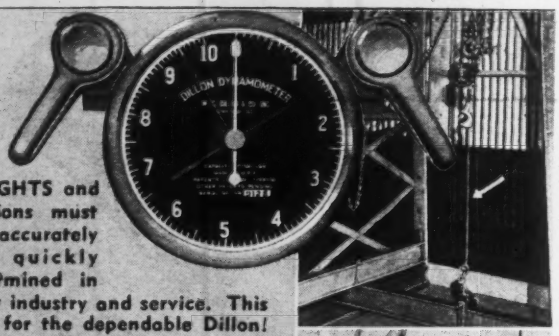

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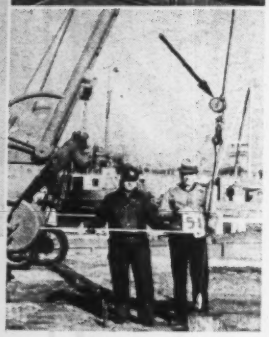

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Continued from page 889

size. For rapid production checking, the signal-light system is much faster than the pointer-and-scale indication; for classification or selection the indication is available. This instrument, too, has four ranges providing readings from ten microinches to 0.003", as well as adjustment for permissible limits when the signal lights are used.

For production inspection, it is convenient to employ a number of these comparator gages operating simultaneously to measure a number of dimensions on a single part. Fig. 42 is a photograph of such an arrangement of electrical comparator gages; here twenty-one separate gaging heads are arranged to check as many dimensions on a master camshaft. In this particular application, thirteen dimensions have tolerances of 0.0005", two have tolerance of 0.001", and six have 0.01" tolerance. Each of the twenty-one gages actuates a lamp which signals immediately if a dimension is outside the permissible limits; a master lamp is also provided, which remains dark if all dimensions are correct but flashes if any one is not within the limits prescribed. Thus the operator need watch only the master lamp; when it indicates that a part is defective he refers

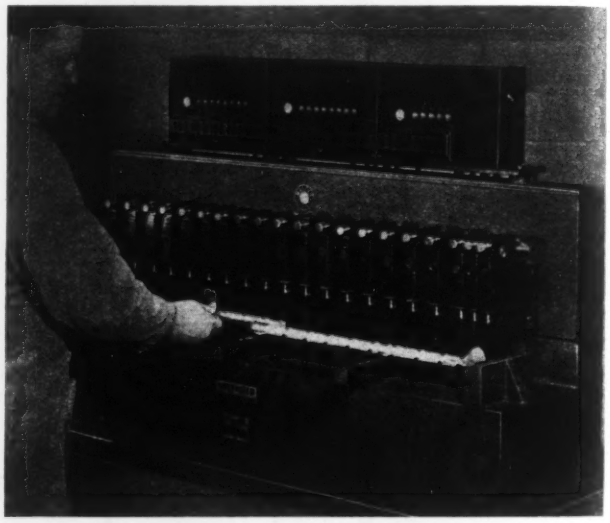

Fig. 42. Multi-point Magnetic Comparator Gage. *(Courtesy The Sheffield Corporation.)*

to the diagram panel to see which dimension is out and in which direction.

An assembly of gages such as the one just described, which inspects many dimensions simultaneously and to any desired tolerance (not necessarily the same for all dimensions) greatly expedites production testing.

It is worth noting that of the five gages just described, only one incorporates an amplifying circuit; the others are based on the simple inductance bridge circuit, and have sufficient output to operate the indicating instrument without electronic amplifiers. Electron tubes are used, however, as relay devices to facilitate the connection of signal lights.

Fig. 43 shows a different sort of measuring system—one designed for measuring fluid pressures, and for recording both steady pressures and fluctuations in pressure. The recorder is not shown in the photograph, which includes a single power supply, four amplifiers, and a number of gage heads and connecting cables. The system operates on magnetic principles, as do those described above, but there are many differences in construction and in operation. These gages are designed to be installed at a point some distance away from the amplifier, and to be connected through a cable; the gage heads are therefore designed to provide compensation for temperature changes. Several different types of gage heads are available in this equipment; some have two arms of an inductance bridge circuit in the pick-

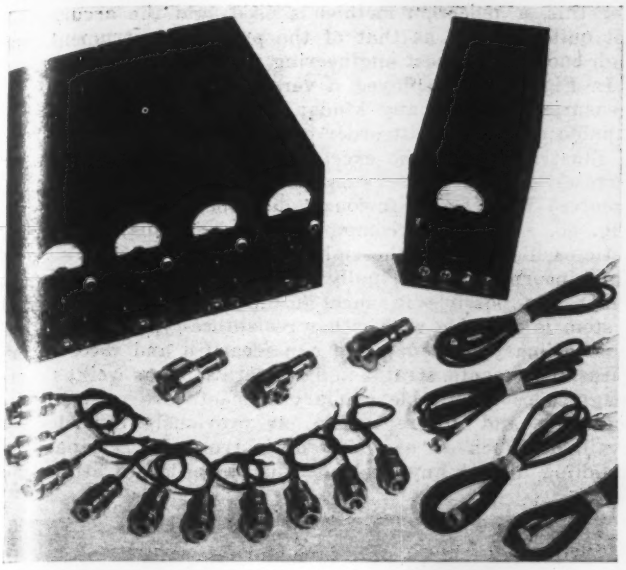

Fig. 43. Magnetic Fluid-pressure Gages, with Amplifier. *(Courtesy Trimount Instrument Co.)*

up, while others have all four arms placed in the pick-up head. The fluid pressure (air, water, steam, etc.) is applied to a diaphragm, to which is attached the moving "armature" of the magnetic element. A carrier system is employed, and the amplifiers are capable of several different modes of operation; they can also be made to record either on a cathode-ray oscilloscope or a magnetic oscillograph. The mechanical arrangement is designed for convenience; as many amplifiers as are desired can be tied together and handled as a unit. An indicating instrument is available for adjustment and inspection of each amplifier.

This magnetic pressure-gage system is representative of a type; the same sort of set-up can be assembled for use with strain gages, accelerometers and other primary elements. Any magnitude which can be represented as a change in reluctance of a magnetic circuit (through movement of an armature usually) can be measured and recorded by such a system.

In Fig. 44 is shown a single-channel carrier-type indi-

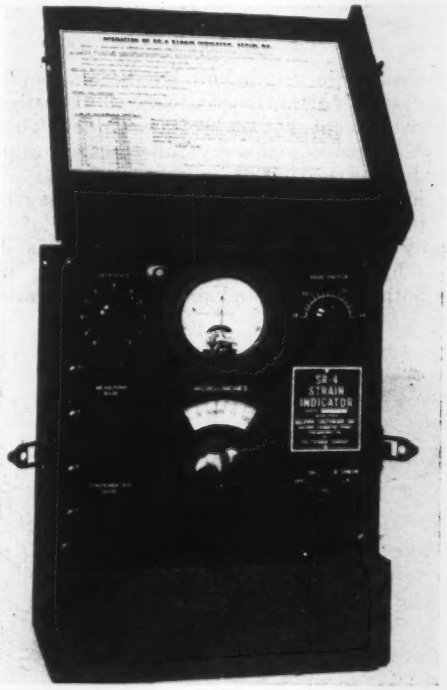

Fig. 44. Portable Strain Indicator. *(Courtesy Baldwin Locomotive Works.)*

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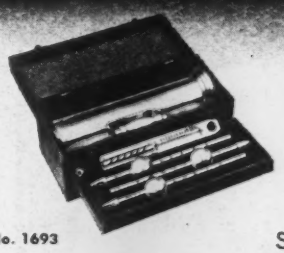
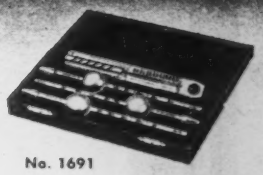

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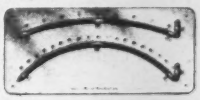
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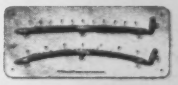
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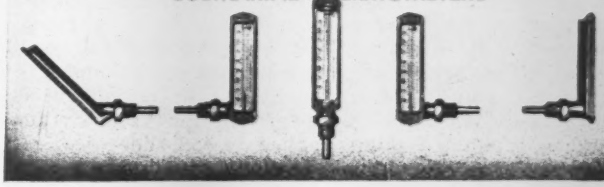

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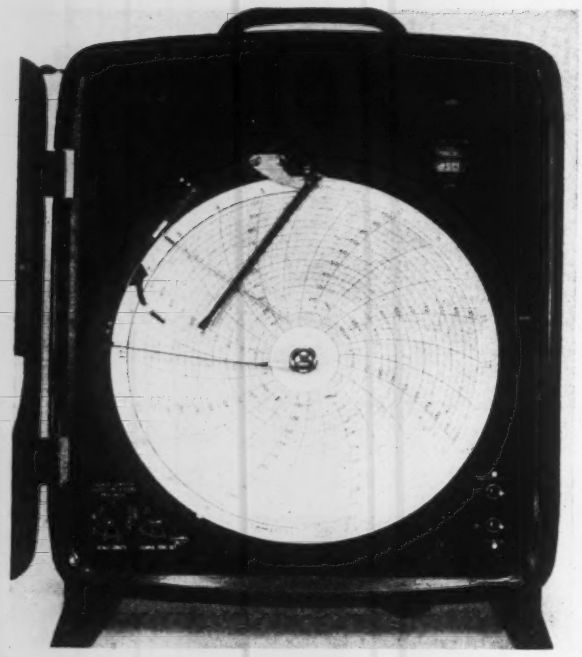

Fig. 45. Static Strain Recorder. *(Courtesy Baldwin Locomotive Works.)*

cator for general-purpose use and for portable use in particular. It is designed for use with wire-type resistance strain gages and, although it may be employed in a deflection manner (within limits)it is essentially a null device, and correspondingly of high accuracy. The portable case contains a 1000-cycle oscillator, a resistance bridge circuit, an amplifier, and a phase-discriminating rectifier circuit; the output of the instrument is indicated on a rugged milliammeter. It is entirely battery-operated—really self-contained. The bridge circuit incorporates a number of refinements: adjustment of sensitivity to permit direct-reading operation with gages of different sensitivities, through a graduated shunt applied to the slide-wire; and availability of extremely wide range of adjustment through a tapped arm while retaining high sensitivity of adjustment of the slide-wire are most useful. The device contains only two of the bridge arms; the other two are to be connected externally so that temperature compensation may be accomplished. (Fig. 44 does not show these external connections.)

This instrument does not have any provision for recording; it requires the attention of an operator. Another somewhat similar instrument, shown in Fig. 45, is available to fill this need: it records the output of a resistance gage bridge circuit on round charts and there is available for it a scanning switch so that the instrument can record in rapid succession the strain magnitudes from as many as 48 separate gages. The record is inked on a round chart and is not a dynamic record but a static record of gage output. For this, a deflection method is used, and the accuracy is not quite so high as that of the previous instrument but high enough for most engineering measurements.

In Fig. 46 is displayed a versatile system for dynamic measurements of many kinds; this set of instruments is capable of the highest order of work. The entire assembly is illustrated with the exception of the primary elements themselves. The power supplies (left) and the amplifiers (center) have been previously described (see Fig. 28 and Fig. 35, and their accompanying descriptions). The magnetic oscillograph at the right is a complete twelve-element unit, incorporating virtually all the operating conveniences which are possible in such an instrument. The complete system is operable with either resistance-type or magnetic-type primary elements, and can measure and record pressures, movements, strains and accelerations, as well as other magnitudes if suitable primary elements are provided. Integration and differentiation, as previously described, is available. Such an assembly of instruments is capable of handling almost any problem. But, in order to attain this type of operation, the equipment has become bulky, heavy, and rather costly; furthermore, it is not so easily operated as to be used except by trained personnel. This sort of apparatus is designed primarily for research applications; not for production testing.

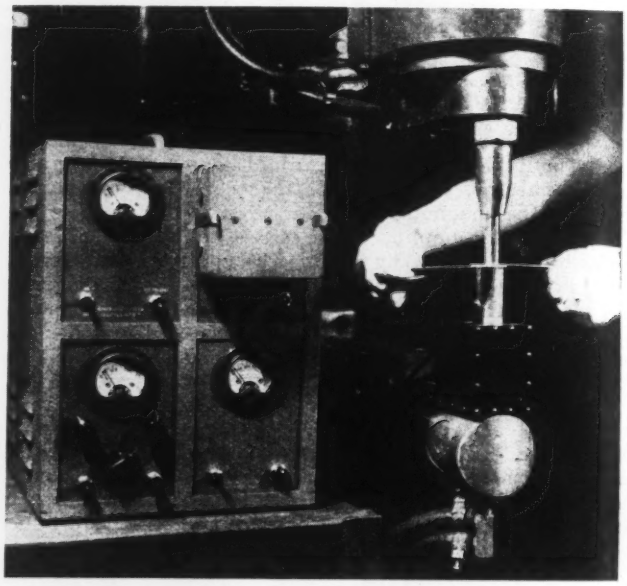

Fig. 47. Welding Current-Force Recorder. *(Courtesy General Electric Company.)*

Another manufacturer of this kind of measuring equipment has produced a convenient assembly of amplifier, power supply and recording oscillograph; it is illustrated in Fig. 47. This is an interesting and versatile system for measuring both electrical and mechanical magnitudes, and

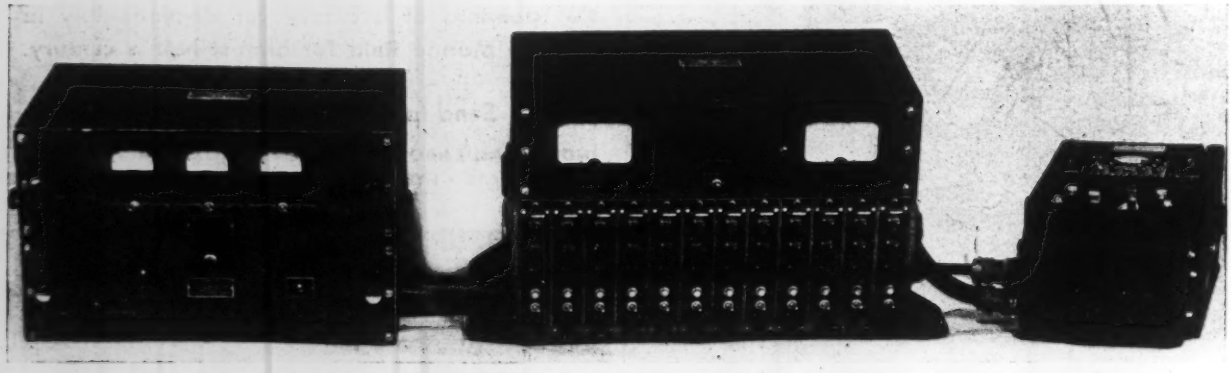

Fig. 46. Complete 12-Channel Electric Gaging System. *(Courtesy Hathaway Instrument Co.)*

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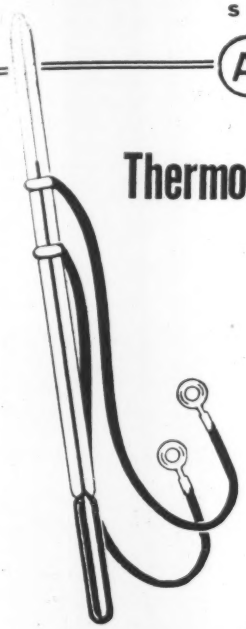

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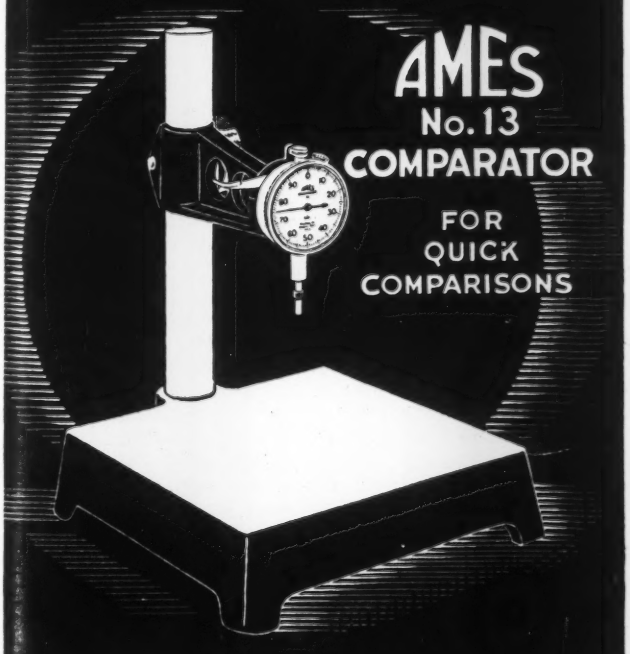

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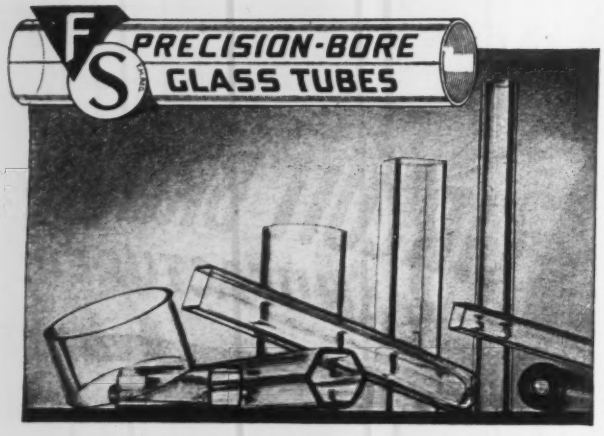

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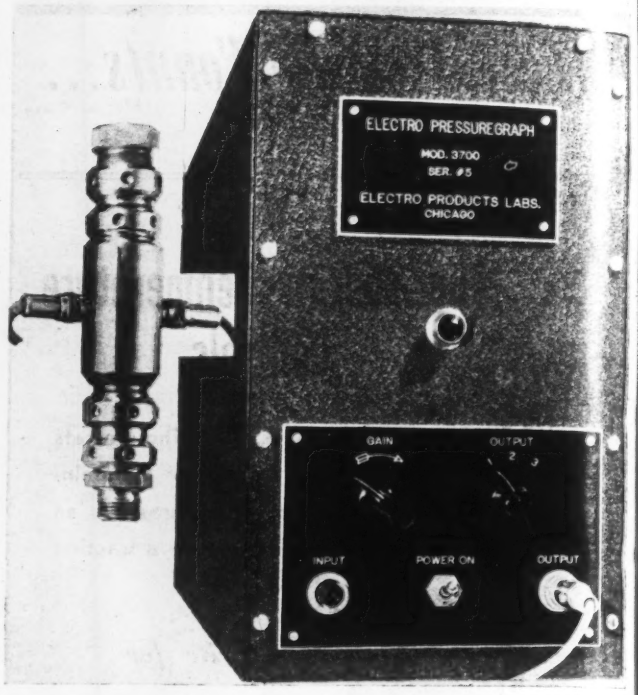

Fig. 48. Capacitance-type Fluid-pressure Gaging System. *(Courtesy Electro Products Laboratories.)*

for recording them against a time scale. It includes a system for measuring force (in terms of strain in a weighbar) and a calibrated shunt for measuring large currents; a small six-element magnetic oscillograph is provided for recording the data. The system was designed primarily for current and force measurements on spot-welding machines; the shunt and the weighbar are built into a special electrode assembly which may be installed in almost any welder. Relay operations, sequences, etc., may be indicated with the remaining galvanometers.

Although this assembly of instruments was specifically designed for welding studies, it should be noted that the same (or other corresponding) units can also be employed for other work. The oscillograph (upper right-hand compartment in the case illustrated) can be employed either with or without the other units here shown. (This oscillograph was described previously; see Fig. 18 and accompanying description.) The carrier-type amplifier (lower left compartment) can operate from wire-type resistance gages, from electromagnetic gages, or from magnetostrictive gages— all commercially available. The 5000-cycle carrier current supply and the amplifier power supply (upper left and lower right compartments) can operate as many as six of these amplifiers simultaneously, so that to extend the system to more measuring channels it is only necessary to provide more amplifiers.

To the writer's knowledge, there is only one commercially-available variable-capacitance pressure gage which incorporates all four arms of a bridge circuit in the pick-up head, and is therefore capable of operating without interference from long cables. This instrument (pick-up head and separate amplifier) is shown in Fig. 48. It employs a carrier frequency of 100,000 cycles per second, and can therefore operate up to frequencies of 20,000 cycles per second if the auxiliary circuits can respond to that frequency; at the same time it responds to steady pressures. With such an instrument detonation studies are possible; previously in order to detect the high-frequency detonation waves it was necessary to employ a device not suitable for static measurements. The instrument pictured indicates its output on a cathode-ray oscilloscope; this trace may be photographed if required. No available magnetic oscillograph can record to the upper limit of frequency response of this instrument.

The devices described thus far in this chapter have be n

essentially measuring devices for research, development, or for production checking—with the exception of the 21-station comparator gage of Fig. 42. But electric gaging devices are extremely effective for routine inspection and checking of mechanical parts in the production line. An example of this appears as Fig. 49; this is an automatic piston-ring inspector which employs a magnetic gaging device to check the width of the gap, and a photoelectric scanning system to inspect the periphery of the ring for trueness. Each ring is separately inspected; those that fall within tolerance limits (for gap width, 0.035"; for trueness of pheriphery, 0.0001") are passed through, while the rejects are diverted into groups classified as to type of defect. The rate of operation is about 1500 pieces per hour.

Another gaging device of this sort is shown as Fig. 50. This also is a production-type gaging machine; this particular one being developed for inspection of shell fuze parts. Reliable and uniform operation of fuzes during firing required that inspection be unusually close; it was necessary to rotate one portion of the specimen at high speed while a measurement of dimension was made; then the piece was stopped so that other measurements could be made and the fuze passed on out of the machine. Measurements such as these can hardly be made at all except by electrical means; even by the photoelectric method employed here such gaging is an accomplishment of note.

Fig. 51 illustrates an instrument designed for meteorological rather than engineering application, but employing an interesting principle which may be applied to smaller-scale measurements. It is called the Ceilometer System, and its function is the measurement (and recording) of cloud heights. The system includes three units: a sender, a receiver, and a recorder, the sender and the receiver usually being separated by 1000 feet. The receiver and the recorder are coupled together through a Selsyn motor system. The sending unit projects a modulated beam of light into the sky, and the receiving unit contains a photoelectric system for detecting the reflected light from the clouds. A discriminator panel filters out signals from the constant background

Fig. 49. Automatic Piston-Ring Inspection Machine. *(Courtesy The Sheffield Corporation.)*

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light and allows only signals from the modulated light to be fed into a tuned amplifying system. The Selsyn motor coupling is used to indicate the angle of signal on the recorder. Thus by triangulation, using the 1000-foot base line, actual cloud heights can be determined from the indicating instrument.* The actual instrument is pictured in Fig. 51A; Fig. 51B is a block diagram of its essential elements.

Fig. 52 illustrates a measuring system somewhat different from any previously described, in that it can measure both magnitude and character, indicating this intelligence on

*It is interesting to compare this device to the newly-announced Western Electric gunfire computer, in which the operators direct range-finders at enemy aircraft, while the intelligence from several of these instruments is combined in an electrical computer. There, however, the measurements are optical and the computation electrical; in the Ceilometer both measurement and computation are electrical.

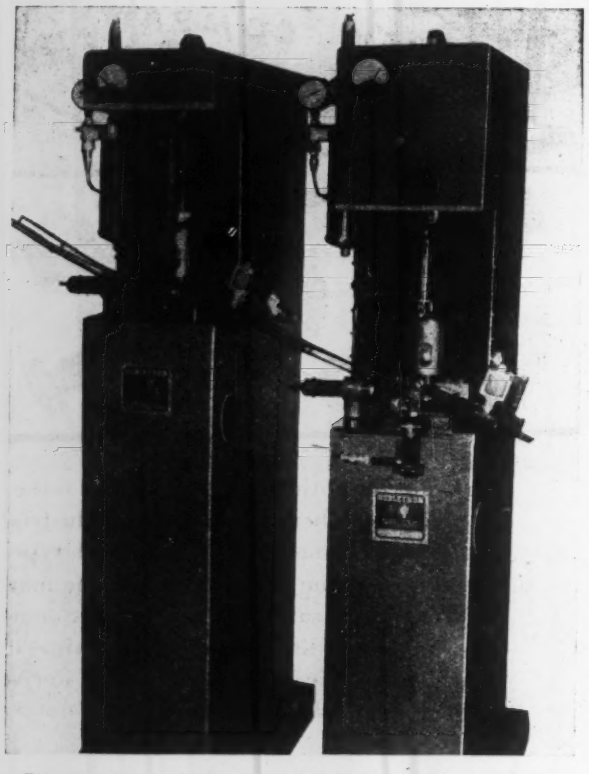
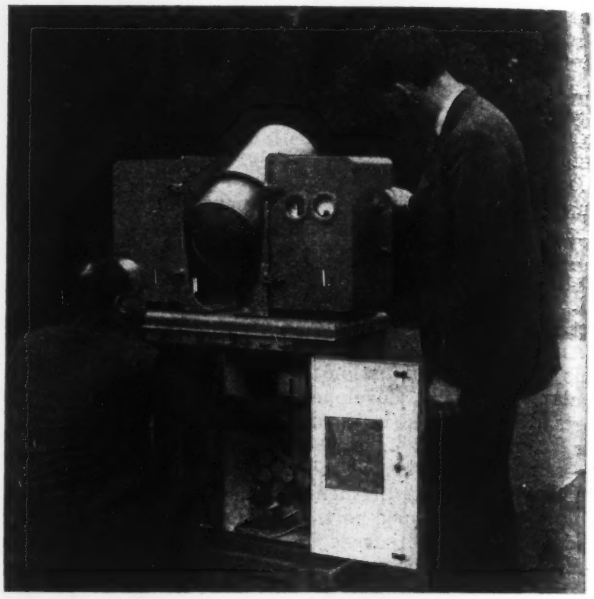
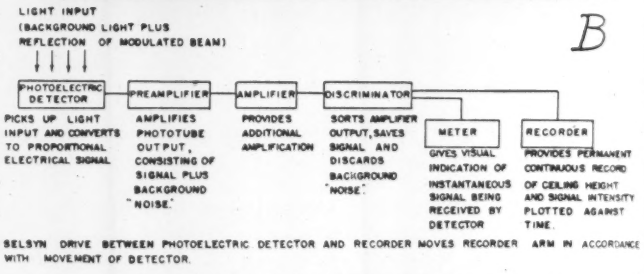


Fig. 50. Automatic Inspector for Ordnance Fuzes. *(Courtesy The Electric Eye Equipment Co.)*

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(BACKGROUND LIGHT PLUS
REFLECTION OF MODULATED BEAM)
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PREAMPLIFIER
AMPLIFIER
DISCRIMINATOR
METER
RECORDER
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AMPLIFIES PHOTOTUBE OUTPUT, CONSISTING OF SIGNAL PLUS BACKGROUND "NOISE."
PROVIDES ADDITIONAL AMPLIFICATION
SORTS AMPLIFIER OUTPUT, SAVES SIGNAL AND DISCARDS BACKGROUND "NOISE."
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PROVIDES PERMANENT CONTINUOUS RECORD OF CEILING HEIGHT AND SIGNAL INTENSITY PLOTTED AGAINST TIME.
SELSYN DRIVE BETWEEN PHOTOELECTRIC DETECTOR AND RECORDER MOVES RECORDER ARM IN ACCORDANCE WITH MOVEMENT OF DETECTOR.

Fig. 51. Photoelectric Cloud-height Recorder. *(Courtesy General Electric Company.)*

pointer-type indicating instruments. It may be described therefore as a *measuring* and *analyzing* system—a system which first measures magnitudes, then performs certain computations, selections or analyses, and indicates the results obtained. It is possible also to record the output of the instruments.

The left-hand instrument in the photograph is a vibration meter, it employs a piezoelectric pick-up, inertia-coupled to the specimen, and therefore sensitive to acceleration. The output of this primary element is amplified by an electron-tube amplifier and then measured by a vacuum-tube voltmeter. Calibrating facilities are provided for

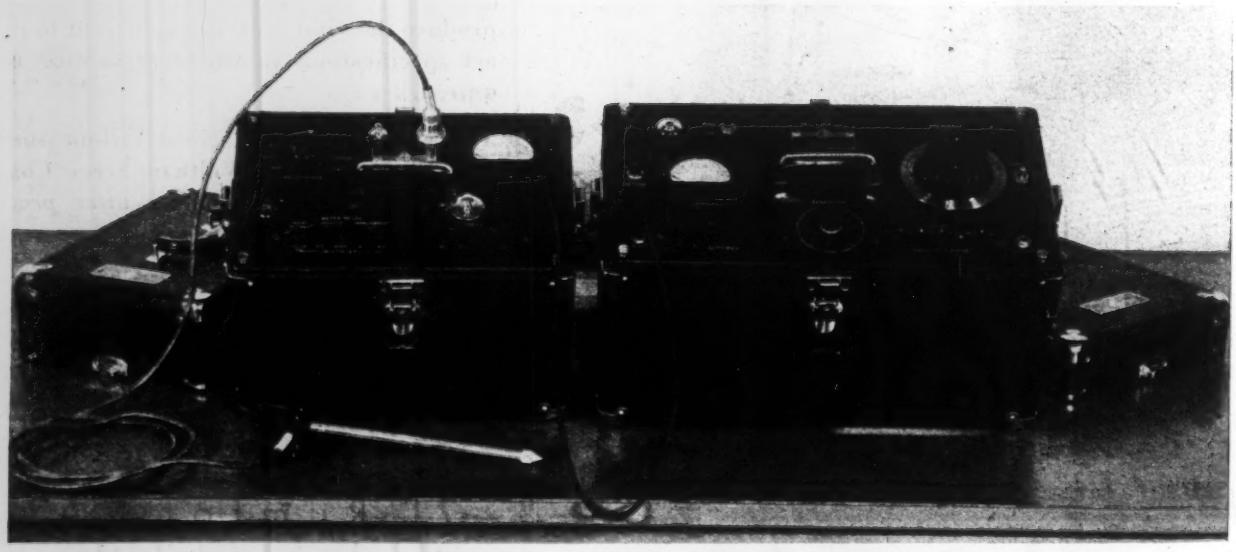

Fig. 52. Vibration Meter and Analyzer. *(Courtesy General Radio Company.)*

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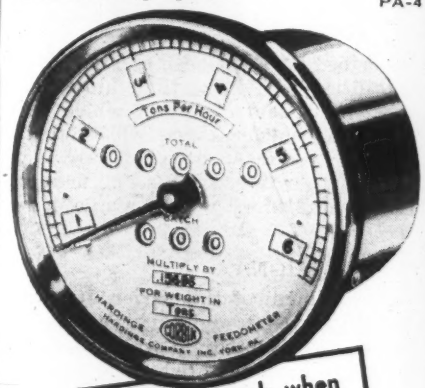

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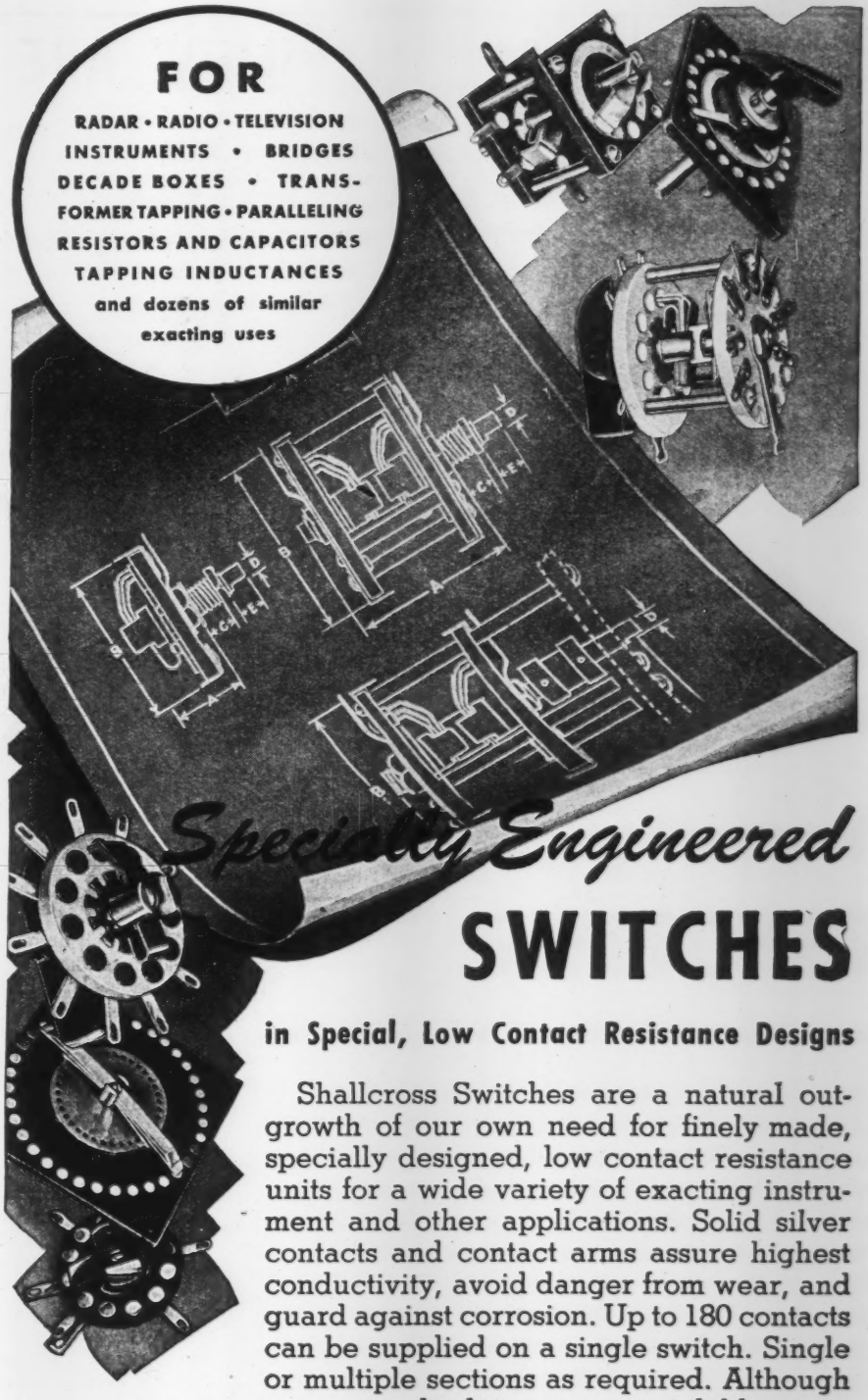

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checking and adjusting the amplifier and the indicating instrument. Two integrating circuits are incorporated into the system, so that the output of the acceleration-sensitive primary element may be integrated once to provide velocity values, or twice to provide displacement values. The indicating instrument is graduated directly, and the device is direct-reading in terms of acceleration, velocity, or displacement. The vibration meter alone, however, does not give any indication of the frequency of the vibration, although its range extends from 2 cycles to more than 1000 cycles per second.

For many applications, the frequency of the vibrations is quite as good a criterion as their amplitude and, so that they may be determined, an analyzer is provided—the right-hand instrument in the photograph. It is essentially a tuned amplifier fitted with an output meter; the tuning is variable, so that a wide range of frequencies can be explored. (The instrument illustrated covers from 2.5 to 750 cycles per second.) At any setting, the instrument responds to an extremely narrow band of frequencies; the width of this band is a constant percentage of the frequency to which the intrument is adjusted. The tuning is continuously adjustable by a dial and a series of range-changing switches.

These two instruments are not expected to provide so complete a picture as can be obtained by more elaborate equipment. They do, however, provide a quick analysis of the vibrational phenomena at any point, and to a degree of accuracy sufficient for many applications. It is possible to extend the use of these instruments by adding a recording device which provides a record of the percentage of every frequency represented within the range of the instrument.

There are many other systems available—far more than could be described in many pages—but the ones which have been listed here are fairly representative of the field. It has not been possible to list all the makers, but an effort has been made to list as many as possible; likewise, as many types of instruments as possible have been included. Even those which have been described have not been treated fully, nor have their full capabilities been more than hinted at. But every day brings new instruments, some of which will be better than these and will replace them, while others will tap new fields. Those described, however, are not ephemeral; the principles they employ will also be used in the newer and better instruments which will be available in the future.

CONCLUSION

This is the concluding installment of this series. Its publication has occupied almost two years, and during this time many new instruments have undoubtedly been developed. Some, in fact, have already been announced since the relaxation of wartime restrictions.

The equipment described in Part II of this book will become obsolete; it will be replaced (we hope) with better. But the principles set out in Part I will not; the new instruments will employ them just as our present ones do. Their employment will be more effective, and the instruments produced more efficient, as we learn more about their true meaning and expression. The permanent value of this book lies in the descriptions—and discussions—of these principles.

The author wishes at this time to express his gratitude to the many readers who have offered comments and suggestions, and to state again his hope that these pages have been (and will be) both useful and interesting. There are omissions, certainly; there are ambiguities and (inevitably) errors, but it is hoped that these will be overshadowed by such good points as this book possesses.

Preliminary Announcement.—As intimated in Mr. Roberts' conclusion, his serial is to be brought out in book form. Work has already begun; a definite announcement will be made on publication date in early 1946.

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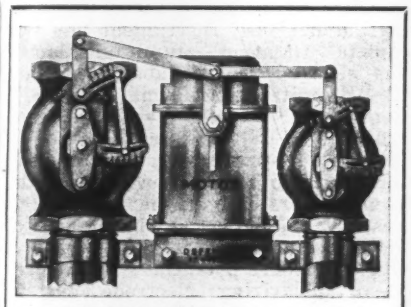

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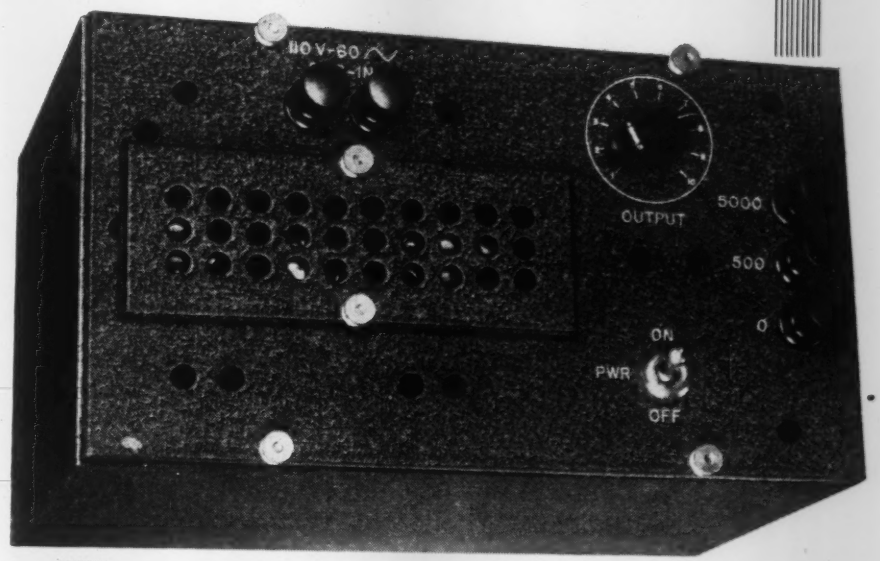

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The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Electric Tachometers

New "Metron Tachometers" are announced in portable or fixed-installation models, also in either battery-operated or a-c.-operated models. Illustration

shows "Metron Type 25A Hand Tachometer." All models utilize a new electrical method whereby no generator (such as the conventional magneto) need be driven, thereby reducing weight of head and servicing of brushes, etc. Head consists merely of a rotating shaft which operates a set of contacts through a positive cam mechanism designed to open and close contacts periodically without resort to spring return. Motion produced is only approx. 1/16" and mechanism is self-lubricating. Head is light and small, so that it can be used where little space is available. This also makes it convenient for permanent installations. In portable models a two-foot cable is provided between head and indicating unit. Cable can be almost any desired length and in fixed installations may reach a length of several hundred feet. Indicating unit may be operated either from batteries or from a 115-volt a-c. power source; operation of either type is the same. Unit consists of a reactance circuit in conjunction with a metering circuit so arranged that, when reactance circuit is energized periodically by power source through contacts in head, deflection of indicating instrument is directly proportional to speed of tachometer shaft. Normal wear of parts in head has no effect upon calibration. It is said that considerable pains have been taken in the a-c.-operated types to insure that variations in the 115-volt supply will not affect accuracy. This has been done by incorporating a voltage stabilizing circuit so that little effect on accuracy is encountered when supply varies from 105 to 125 volts. In the battery-operated types one 1" flashlight cell is used and provision is made for checking condition of this battery and compensating for reduced voltage. This is done by placing rotary switch (on front of unit) in the "TEST B" position and adjusting a small rheostat. Less than one milliampere is drawn from this battery, so its life is practically equal to shelf life. When tachometer is permanently installed in aircraft or motorized equipment systems, batteries are used and variation in voltage is automatically compensated. *Ranges and scales:* Standard models are three-range and range can easily be selected with thumb while reading is being taken; 60-cycle synchronous speeds are well up on scales; special ranges can be furnished; heads operate on either clockwise or counter-clockwise rotating shafts and are not affected by magnetic fields. — *Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Area Meters for Large Flows

New "Rota-Sleeve" is a flowmeter of the variable-area class available in either of three types: (1) free-float or "rotameter"; (2) cone-and-disk; (3)

Fig. 1.

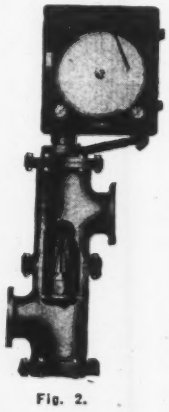


Fig. 2.

cylinder-and-piston. A unique basic-design feature is that the essential element, in the form of a sleeve, fits in standard pipe tees of any material or of any make, from the 3" pipe size up to 20" pipe size (up to 72" in future models being scheduled). Not only is sleeve insert available in tapered, slotted or fluted forms—geometry determining type and hence some characteristics—but there is a choice of shapes of pistons or floats, including maker's "Stabl-Vis" float which compensates for variations in viscosity of metered fluid, so that manufacturer can guarantee straight-line calibration (important in many applications) as well as wide ranges (10:1 standard, 20:1 practicable) and accuracy comparable to that of more expensive flowmeters. "Rota-Sleeves" are available for the highest line pressures which the pipe line itself can withstand: sight-glass models (Fig. 1) having safety features and recording or recording-controlling models (Fig. 2) having magnetic couplings instead of stuffing-boxes. "Rotasleeves" may be made of corrosion-resistant as well as of commonly-used metals and alloys.—*Fischer & Porter Co., 9230P, County Line Road, Hatboro, Penna.*

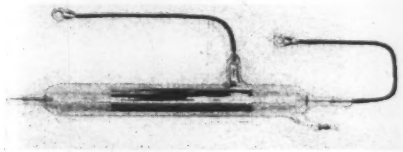
Titrometer

New titrometer determines free and combined acidity of material in either aqueous or non-aqueous highly colored or opaque solutions; was originated by Shell Development Labs primarily for determining acidity of highly complex mixtures of lubricating oils, either opaque or so dark in color that routine acidimetric color titrations could not be made. Potentiometer method is reproducible, and titration medium is capable of dispersing or dissolving sufficient quantities of the water-insoluble materials under test. Instrument has two complete titration stands. Calomel-glass electrode is readable to within 0.02 pH units. Instrument scales and potentiometer circuits give a range of —1.65 to +1.65 volts readable to 0.5 millivolts. Instrument is continuously indicating. No prior knowledge of the magnitude or sign of the potential is necessary, as electrical characteristics of circuit and indicator allow measurement of system's potential without danger of polarizing electrode system. Two titrations can proceed simultaneously owing to dual feature of system; and the two diverse electrode systems may be left permanently set up. Titrometer is portable, has a power consumption of ten watts, and is suitable for continuous duty. Entire elec-

tronic system is shielded and enclosed in a metal housing. No batteries or transformers are required. New titrometer has been found suitable for conducting A.S.T.M. Proposed Method of Test for Saponification Number of Petroleum Products by Electronic Titration and also for A.S.T.M. Tentative Method D-664, "Neutralization Number of Petroleum Products by Electrometric Titration."—*Precision Scientific Co., 1750 North Springfield Ave., Chicago 47, Illinois.*

Geiger Counter Tube

New "Types TA-B1 and TA-B2" Geiger Counter Tube, meeting requirements of many radioactivity detection applications in the fields of biology,



chemistry, geology, metallurgy, physics and medicine, is constructed of pyrex glass, with metal-to-glass seals. Sensitive portion measures 8½ cm. by 19 mm. diameter. Inner surface as coated with a silver mirror film, serving as one of the electrodes. Combined thickness of glass wall and silver film is approx. 0.006". While especially designed for the detection of beta particles of 0.7 Mev. or higher energy, gamma, cosmic and x-rays can also be detected. Tetramethyllead vapor filling assures wide, flat plateaus, good sensitivity and long life. Counting rate above 14 kv. is nearly 13000 per minute. Counter is self-extinguishing. Clean, sharp pulses are obtained with a simple single-stage amplifier. Developed at Columbia University, experimental models of this type have been used successfully. These counters are now available, filled, tested and ready for use.—*Technical Associates, 3730 San Fernando Road, Glendale 4, California.*

Industrial Thermometers

New industrial mercury-in-glass thermometers, said to be the result of "generations of practical experience in the engineering and development of temperature indicating instruments," are of a new design embodying a number of improvements, among which are cases made of satin-finish brass constructed to permit wider angle of vision; scales made of silver-plated brass with bold black graduations; red glass reading column which eliminates possibility of eye strain and assures accurate reading; double-thick glass secured by a four-piece interlocking bezel under spring tension; triple-distilled mercury for thermometers from —40° to 1125°F. Separable sockets are available in all types of metals and alloys, and in a wide range of sizes for individual applications. Rigid construction and proper insulation protects glass tubes from breakage and from contact with cases. Taper bulb chambers are precision ground and held to a tolerance of ±0.001" for contact with inner wall of separable socket for speediest response to temperature

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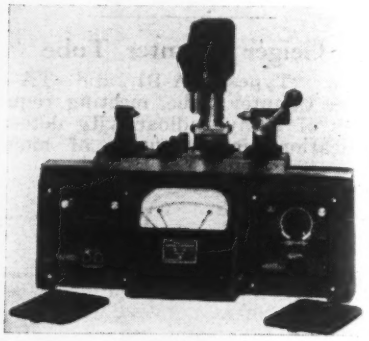
changes. Mercury oxidation in bo e is prevented by inert-gas filling fter evacuation.—*Engineering Dep't., Beller Instrument Co., 132nd St., and 9th Ave., Richmond Hill 18, N. Y.*

Surface Smoothness Indicato

New "Quick Scanning Surface Comparator," for inspecting the smoothness of finished surfaces, consists of a photoelectric scanning head, a self-contained amplifier with calibrating controls, a "finish meter" with adjustable tolerance markers, and a ball-bearing work-holding carriage. Critical adjustment of scanning head is unnecessary. Its response is independent of direction of finish grain. Amplifier is contained in the base and its zero setting, calibrating and sensitivity controls are mounted on front panels of base. "Finish meter" is graduated so that readings represent smoothness of part being inspected as a *percentage* of the smoothness of the standard used for setting Comparator. If desired, this value may be converted to units currently used to express surface finish smoothness. Work-holding carriage has a 7" travel and a 6" cylindrical capacity. Flat parts are placed on its table and cylinders are held between centers or placed on vees with Norbide inserts. Instrument is as rapidly operated as are conventional comparators used to inspect size; and requires no more skill.—*The Comptor Co., Waltham, Mass.*



Glassworking Lathes and Burner Assemblies

New improved models of bench- and floor-mounted glassworking lathes are announced; also numerous styles of burners, burner assemblies and attachments. Bench models (one shown in

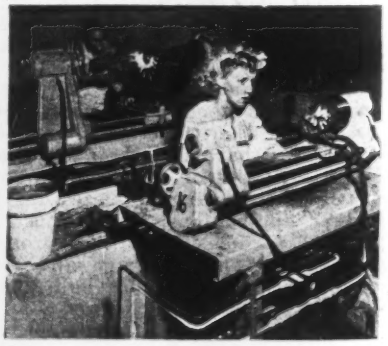


Fig. 1

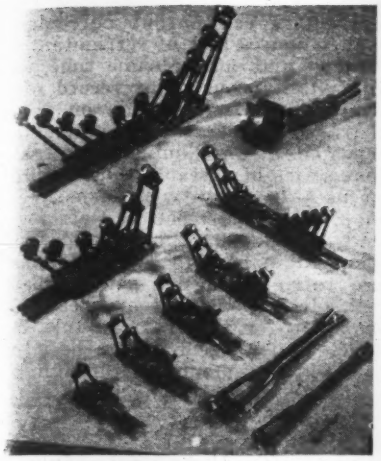
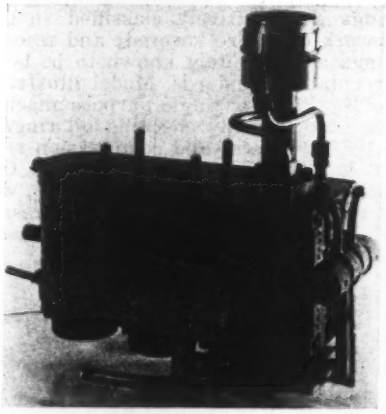


Fig. 2

foreground of Fig. 1) have three-point support to insure that warping of bench surface does not impair accuracy of alignment. Total accumulated error for full extended length is under 0.002" including sum of parallel and coaxial error for both headstock and footstock. Ground-finish boxways are integral with normalized cast-iron bed and are completely covered by an apron which acts as a heat shield, preventing thermal misalignment and keeping broken glass, etc., from falling on sliding parts. *Burners* operate on oxygen-hydrogen or oxygen-gas; pressures can be as low as 10 to 15 lbs./in.^{2} for oxygen and 1 lb./in.^{2} or less for hydrogen or gas. Nearly-complete carburetion within burners eliminates intense light and makes reducing portion of flame much shorter than that of average burner, so that glass may be worked much closer to burner tip: ¾" to 1½" distance except for the largest work. Assemblies (Fig. 2) are available in standard and large size, from two-fire to twelve-fire. Various parts are always available.—*Litton Engineering Laboratory, Redwood City, Calif.*

Oil Vapor Vacuum Pump

New "Model T" vacuum pump 11⅛" high, 3¾" maximum overall width, is water-cooled and weighs 12½ lbs. It requires 2 oz. oil and has ultimate



vacuum of 2×10^{-7} mm. mercury at 25°C. Standard equipment: two boiler heaters, charcoal baffle heater, hand-operated valve control and stud-mountings. Speed bushing is 3/16" to 5/16" O.D. tabulations (other ranges avail-

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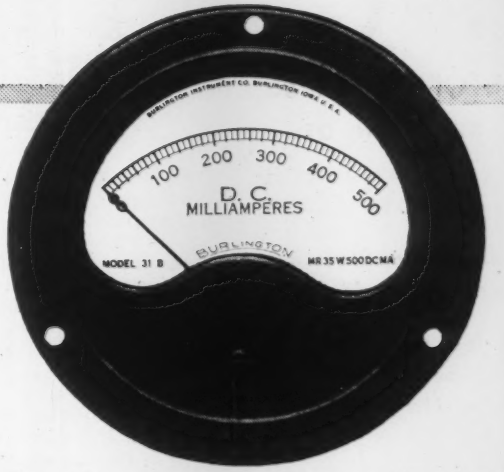

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able). Forepump outlet is ½" copper tubing; roughing pump outlet is ½" copper tubing. Pump is constructed of copper cylinders with tinned steel flange plates.—*Litton Engineering Laboratories, Redwood City, Calif.*

Dew-point Recorder

New dew-point recorder, permitting exceptionally close control of effects of water vapor in air or other gaseous mixtures, is especially applicable to

furnaces utilizing prepared gas atmospheres, or wherever dehydrated air or a gas mixture of controlled moisture content is desirable, as in chemical and food processing industries, drug preparation, etc. New recorder can provide a virtually continuous record of humidity within a temperature range of —70°F. to +60°F. Precise and frequent adjustments of the various constituent gases in the atmosphere can thus be made to compensate for differences in humidity. Or if humidity control of the air or gaseous atmosphere is used, permanent information concerning its dew-point is provided. Instrument utilizes dew-point cup principle; its operation is therefore independent of nature of gases. Presence of "impurities" in furnace gases (such as H_2S or SO_2) has no effect upon accuracy; hence analysis of furnace atmosphere is unnecessary. Principal units of recorder are a dew-point cup with mirrored surface which can be refrigerated at varying temperatures, a thermocouple which is connected to a recording potentiometer, and the refrigerating unit with its associated circulating system. In operation a stream of the furnace gas after filtering is directed against mirrored surface of dew-point cup while refrigerant circulates within cup. As temperature of the refrigerant drops —and with it mirror temperature—a film forms on mirror surface when dew-point temperature of gas is reached. As soon as film forms, it prevents reflection of a light beam to a photocell and alters cell output current. This change causes flow of refrigerant to be shut off and, at the same time, causes an instantaneous point record of that temperature to be made on recorder chart. This operation is automatically repeated at three-minute intervals so that series of instantaneous recordings forms a virtually "continuous line" for the 24-hour chart period. Refrigerating unit, of the small household type, is mounted in base of housing. Above it are refrigerated dew-point cup, light cell, etc., as well as an electron-tube amplifier for the thermocouple. Sensitivity of new recorder can be adjusted by controls mounted through front panel.—*Surface Combustion Corp., Toledo 1, Ohio.*

Automatic Piston-ring Inspector

New "Automatic Piston Ring Inspector" is said to be the first gaging machine ever developed for the full automatic checking of piston rings.

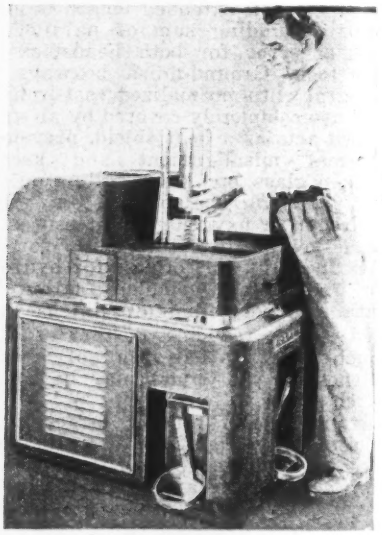


Fig. 1.

With it, 100% inspection of the gap and periphery is not only made possible but is said to be much more accurate and less expensive than sample checking by hand. Uniform quality of accepted parts is assured; salvageable rings are positively classified so that rework costs are lowered; and rejected rings are definitely known to be below acceptable standards. Model illustrated in Fig. 1 is a single-purpose machine for automatically checking oil rings of 0.108" thickness and compression rings of ⅛" thickness, both of 5.750" O.D. Gap in both rings is 0.070" wide, with a tolerance of ±0.0035". Compression ring is tapered, while oil ring has a

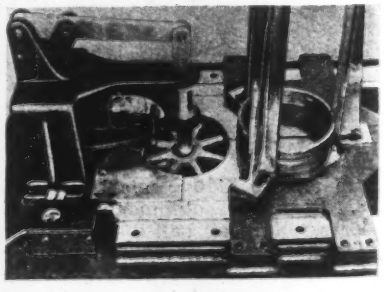
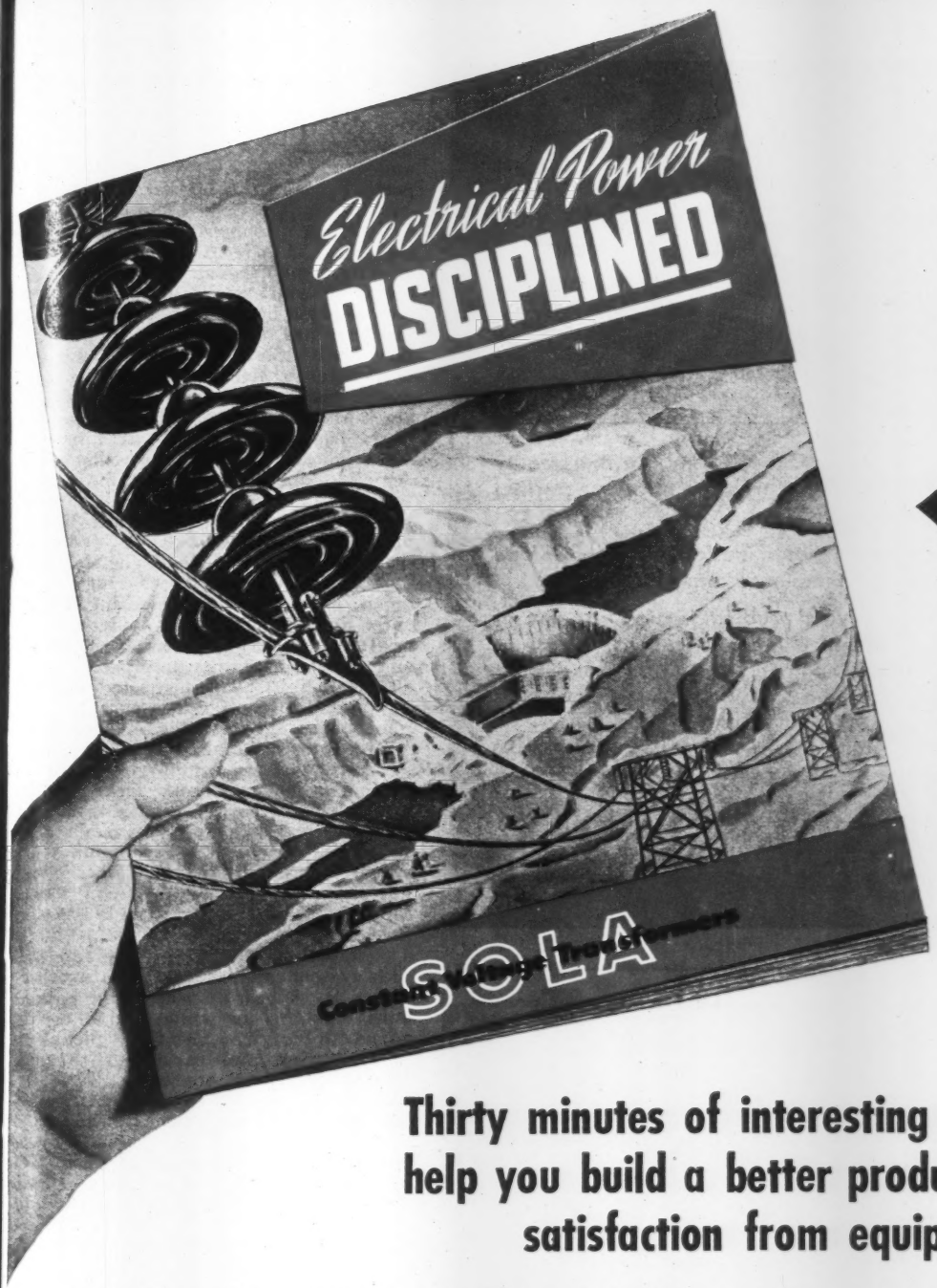


Fig. 2.



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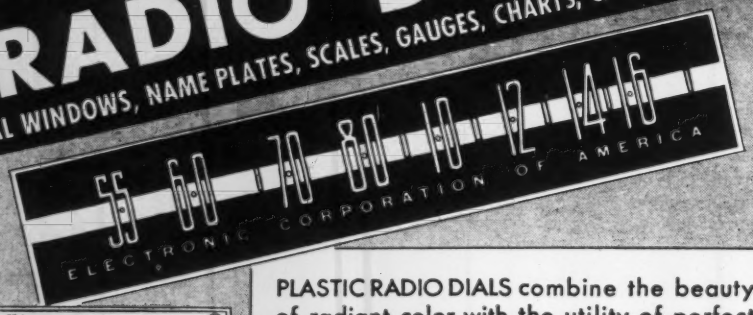

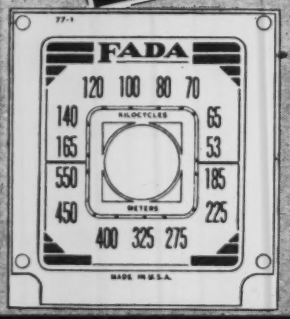

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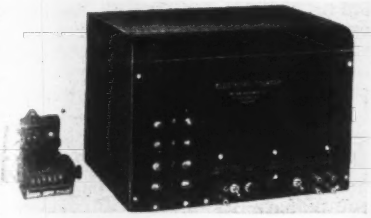
profiled periphery. Machine will check an average of 1500 of these rings per hour; can be adapted to other sizes and types of rings. It segregates rings into three groups: (1) acceptable periphery and gap, (2) reject gap and (3) reject periphery because of failure to meet requirements. Checking and classification are automatic, operator having but to load rings into feeding device. Electric circuits, photocells, Micro-switches, solenoids and relays actuate gaging and selector devices. In Fig. 2, top of machine has been removed to reveal feed device and other mechanism. Automatic cycle starts with feed slide moving to rear, selecting bottom ring from stack and carrying it into gaging position formed by the 180° arcs in feed slide and stationary compression plate. As slide and compression plate come together, ring is compressed so that gap is closed and gap width determined. A deviation of 0.001" from the master can be detected. Vertical feed spider then descends onto ring, pushing it into a constantly-rotating master ring. Rollers on ends of spider fingers assist in properly positioning the piston ring opened to its normal operating position. A light beam projected through an optical system scans outside periphery of ring where it is in contact with master ring while it makes slightly more than a complete revolution. If ring is not sufficiently light-tight at any point on periphery, light passing through clearance energizes a photocell which in turn sets up a holding circuit by means of a relay. This relay is not energized if the piston ring is acceptably light-tight (within 0.0001", i.e., a clearance of 0.0002") while 0.0003" will cause a ring to be rejected. This system can be set for whatever tolerance is desired. Inspected ring rotates with master ring while feed slide returns to original position, picks up another ring and carries it through the gap-checking operation. Then, as this second ring is positioned in rotating master ring, previously inspected ring is ejected onto two solenoid-operated selector shutters or trap doors. If ring is acceptable, both shutters remain closed and ring slides out front of machine onto a rack; if ring is a reject because of either periphery or gap, selector shutters permit the ring to fall by gravity into reject stations on sides of the machine. A spring-loaded clutch throws driving mechanism out of gear should machine jam by reason of rings being laced together while loading into feeding mechanism. — *The Sheffield Corp., Dayton 1, Ohio.*

High-speed Counter

New two-decade electronic high-speed counter is particularly applicable for counts exceeding 10 per second; and in installations where mechanical counters would wear out too soon. Used alone as a two-decade instrument, its maximum count capacity is 100. A tube-operated relay is provided for cases where the quantity to be counted exceeds 100. The relay has an s-p.d.t. contact arrangement brought out to terminals on front panel and operating once for each 100 counts. An electromechanical counter may be connected in series with these terminals and an appropriate external power source.



such as the a-c. line. Each 100 counts of the electronic counter will then cause one operation of the electromechanical counter. When relay and an external mechanical counter are not involved, the two-decade electronic counter may be used alone, at counting rates up to 20,000 per second. Instrument comprises an input section, suitable for any of these four types of input circuits: (a) contact closure; (b) pulse signals; (c) sine-wave signals; (d) square-wave signals. It further consists of two standard counter-decades (designated "units decade" and "tens decade"), an output relay stage, and a power supply. For application problems where an operation is to be controlled or a signal given after a predetermined number of counts special designs may be made. The two-decade electronic counter comes complete with power supply, ready for operation from a nominal 115-volts 60-cycle a-c. power line. No special tubes are required. Outside dimensions of the cased instrument: width, 13½"; height, 8⅞"; depth, 10". Weight complete, 26 lbs.—*Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.*

Multiple Bulkhead Connectors

New double-disconnect type bulkhead connector is said to be particularly adapted to stationary wire installations, such as on aircraft, where quick

connection and disconnection of individual circuits from either side of mounted bulkhead connector is desirable. Permanent current-carrying members extend from both sides of the bulkhead part; are of same design as AMP knife-switch splicing terminal; therefore terminal may be connected or disconnected from multiple connector member merely by holding it vertically in contact with that member and then pulling back. Resulting connection is said to be a perfect 4-point contact giving maximum electrical and mechanical service performance. Plastic covers snap easily into place over wire connec-

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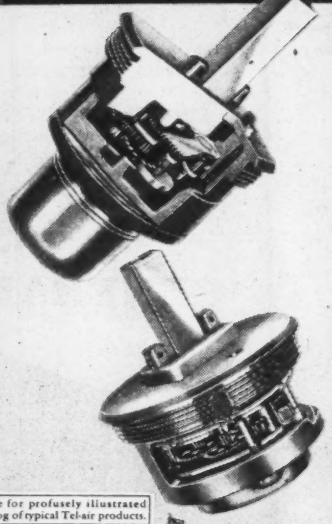

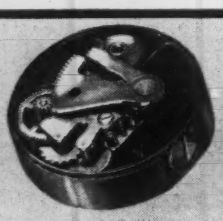

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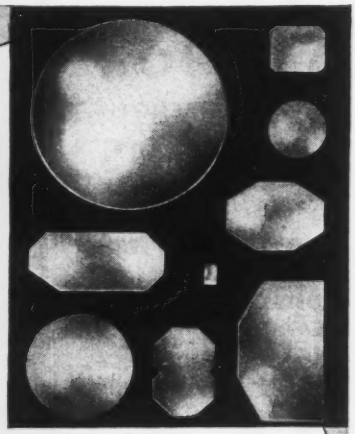

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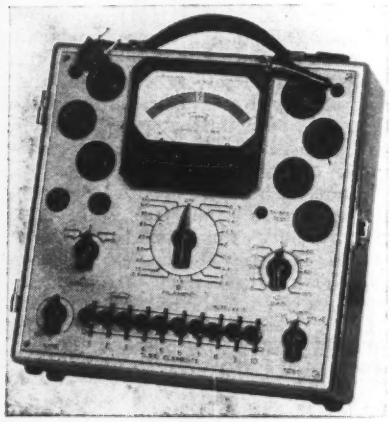
tions in such a way as to secure and insulate connections; and entire installation can be made an air-tight section of panel or mounting. Housing prevents accidental disengagement and does not take any of tensile strain of wires since that is accomplished by each individual knife-disconnect splice. "AMP Bulkhead Connectors" may be ordered to accommodate as many connections as desired with different combinations of wire sizes from 22 to 10 inclusive.—*Aircraft-Marine Products, Inc., 1591 North Fourth Street, Harrisburg, Penna.*

Tube Tester

New "Model 2431 Tube Tester" has a flexible test circuit which provides for "tube value" test, short and open element test, plus a transconductance



comparison check for matching tubes. Three-position lever switching is said to make this one of the speediest and most flexible of all tube testers, since it provides simplicity in operation and still gives individual control for each tube element. Long-scale instrument (4" size) carries maker's guarantee against defects in workmanship or materials. Multicolor scale makes it easy to quickly determine condition of all tubes. Case is tan with brown trim. 10" × 10" × 5¾", with a sturdy leather strap handle and detachable hinged cover.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*

Miniature Pentode with Twice Previous Signal-to-noise Ratio

New miniature "6AK5" electron tube, designed by Bell Telephone Laboratories, is for broad-band, high-frequency amplification essential to coaxial cable systems; and will probably be used in future FM and television equipment. It was developed for broad-band carrier systems and is said to have high transconductance, low capacitances, low noise, and high input resistance. It is a pentode tube with indirectly-heated cathode and has the suppressor grid tied internally to the cathode. It is capable of operating satisfactorily at frequencies up to approx. 350 Mc. Characteristics of the 6AK5 vacuum tube are: maximum diameter, ¾"; maximum seated height, 1½"; classification, pentode; type of cathode, indirectly heated; filament or heater voltage, 6.3 v; filament or heater current, 0.175 amp; normal plate voltage

120 v; normal screen voltage, 120 v; normal grid voltage, 2 v; normal plate current, 7.5 ma; normal screen current, 2.5 ma; normal transconductance, 5000 μ mhos; input capacitance, (with shield), 4.0 μμf; output capacitance (with shield), 2.0 μμf; and plate-grid capacitance (with shield), 0.01 μμf.—*Western Electric Co., Inc., 195 Broadway, N. Y. 7, N. Y.*

Plant Intercommunication Control

New "Temporator" voiceless intercommunication control system is said to bring time, cost, employee, production, materials, inventory, shipping under instant, complete, central control and to integrate and coördinate other related plant-management activities. Up to 4000 messages per day may be transmitted directly to and from employees through one operator seated at a 6-unit central control board (Fig. 1) connected with any number of sub-station dispatchers (Fig. 2). Speed is attained through visible signal dialing. Communications are dialed. Symbols identify each production, operation, material, employee, order, lot part number, etc. Combination of symbols delivers desired directive or report. Symbols are flashed upon and are visible simultaneously at both central control board and any designated sub-station dispatcher. "Temporator" is said to be adapted in whole or in part to any size organization and to any situation where essential data must be quickly assembled. It is installed without interfering with present plant layouts.—*Temporator Div., Simplex Time Recorder Co., 29 Lincoln Street, Gardner, Mass.*

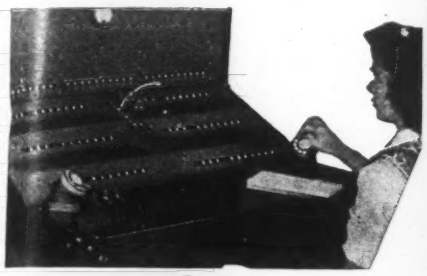


Fig. 1

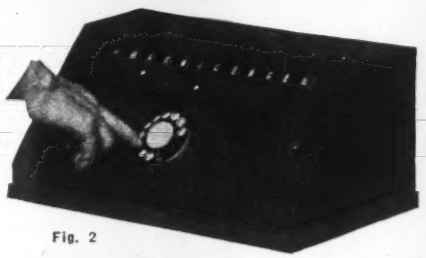


Fig. 2

Diesel-engine Safety Control System

New "Type R-18" safety control system is for the shut-down of diesel engines, when temperature of circulating-water system becomes too high, or when there is insufficient lubricating oil pressure. System operates by means of a pressure-responsive unit, connected in engine's lubricating-oil system, and a thermostatic by-pass valve installed in circulating water system. Pressure-

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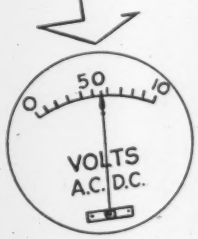
Rectifier Assembly



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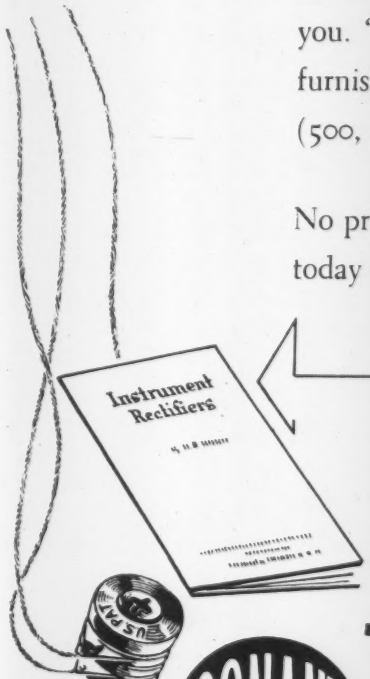

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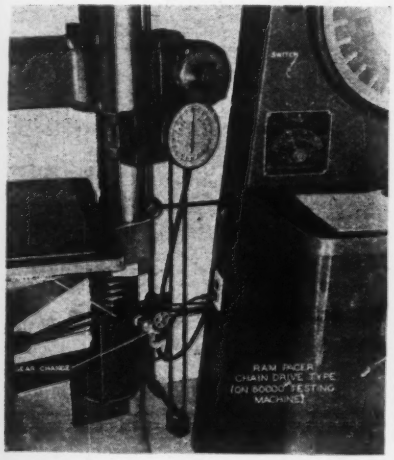
responsive unit houses a bellows which expands upon drop in pressure. This in turn releases a trigger so that the rod and the spring operate the fuel pump or governor lever to shut down the engine. This drop in pressure (and consequent shut-down of the engine) may be caused by failure of the oil supply or the opening of the thermostatic by-pass valve due to increase in circulating-water temperature. This self-operated system does not require any electrical power or additional accessories as required by some shut-down and alarm systems, thereby eliminating electrical troubles. — *Viking Instruments, Inc., Stamford, Conn.*

Testing-machine Loading-rate Controller and Deflectometer

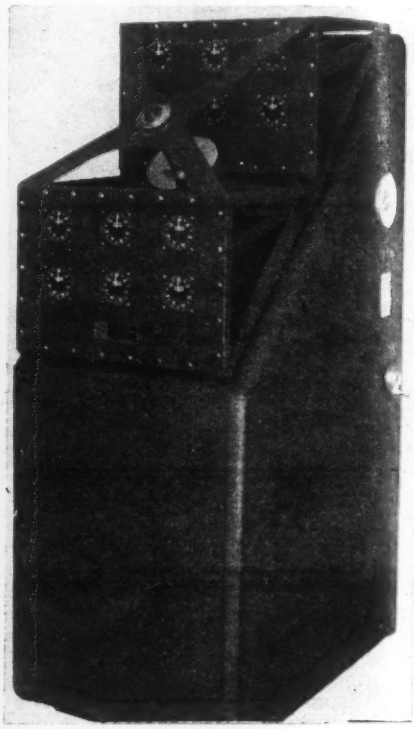
New "Southwark Ram Pacer" permits loads to be applied at predetermined speeds in testing metals, woods, plastics, etc. It attaches to a standard



hydraulic testing machine, gives control over the crosshead movement at eight preset speeds: 0.01″, 0.02″, 0.05″, 0.1″, 0.2″, 0.4″, 0.5″ and 1″ per minute. Speeds are obtained by gear changes on synchronous motor drive unit which is attached to fixed frame of machine while dial portion of apparatus is attached to moving crosshead. Pointer sprocket wheel and sprocket wheel on drive unit are connected by an endless weighted chain. With the gear selected for a certain speed, hydraulic valve of testing machine is opened until loading head rises to a point where dial pointer stands still. This means that pointer sprocket and motor-driven sprocket below are moving at exactly the same speed. Viewable). Forepump outlet is ½″ copper tubing; roughing pump outlet is ½″ copper tubing. Pump is constructed of copper cylinders with tinned steel flange plates.—*Litton Engineering Laboratories, Redwood City, Calif.*

Instrument Vibrator

New instrument vibrator produces circular vibratory motion on a plane 45 degrees to the horizontal, as required by instrument specifications. "Force ac-



tion" is produced by an off-center rotating weight, acting at center of gravity of vibrating assembly. This assembly has freedom of motion in all directions on the 45° plane. Adjustable force oscillator consists of two unbalanced weights enclosed in a circular shell. Both have the same weight-radius product. They can be turned to coun-

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terbalance each other to give no centrifugal force. By turning one part with respect to the other they may be set to give additive centrifugal forces. Oscillator is driven by a ½-hp. constant-speed motor through a variable pitch pulley to give stepless speed variations from 500 to 3,000 r.p.m. Safety clutch prevents excessive torque being applied when starting. Speed control handle is located at front of machine; tachometer is located on side panel. Instrument is 32" long, 23" wide, 61" high; has a 12" × 18" panel. Vibration amplitude range is 0 to 1/16" and max. instrument load 24 lbs.—*Krouse Testing Machine Co., 573 East 11th Ave., Columbus 3, Ohio.*

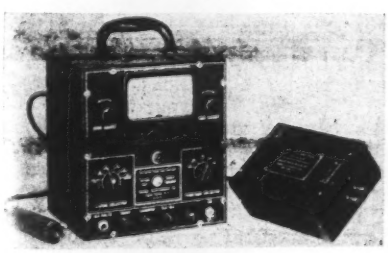
Electric Power Analyzer

New "Dual-purpose Electrical Power Analyzer," designed for shop and portable service, has knife-edge pointers which permit closely reading volts,

amperes and watts to tenths of a scale division, but can also be read from as far as fifty feet. "Model 88-1" (illustrated) is a dual-purpose unit with flush pull rings for either panel mounting or portable service. "Model 88" is portable and, although it has no provision for panel mounting, is suitable for such use if desired. Analyzers are furnished either complete with "tailored-to-fit" lead equipment, with current transformer unit, test report forms and efficiency data packed in a separate carrying case; or with a current transformer equipped with leather carrying handle and threaded terminals but without connecting leads. Mahogany or fabric-covered cases are available. A-c. ranges: 0/1.5/5/15/50/150/300 amps., 0/150/300/600 volts, 0/300 min. to 240,000 watts.—*Niagara Electrical Instrument Co., 204 Franklin St., Buffalo 2, N. Y.*

Vacuum-tube Voltmeter and Amplifier

New "Model 451" vacuum-tube voltmeter and amplifier for laboratory work in industry, universities and like institutions is suitable for measuring am-



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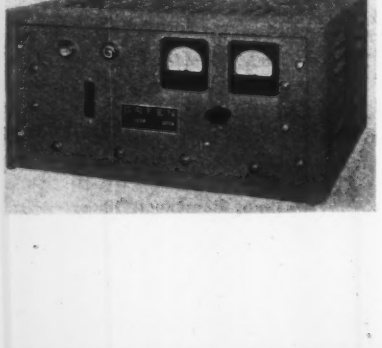
plifier gain, network response, output level at audio and radio frequencies, especially in the television and broadcasting field. Its 25 millivolts a.c. on the lowest range, and 1000 volts on the highest range, as well as its 10 c.p.s. to 700 Mc. frequency range and the 7 $\mu\mu$f input capacity, are said to give this unit excellent sensitivity, voltage range, and capacity; and to permit comprehensive current and resistance measurements. Other features: single linear scale for all voltage and current scales, single zero adjustments for all a-c. and d-c. ranges, voltage-regulated supply, accuracy 2% of full scale values, large overvoltage capacity, fuse located on panel. Weight, 20 lbs.; size 10¾" × 9" × 8".—*Reiner Electronics Co., Inc., 152 West 25th Street, New York 1, N. Y.*

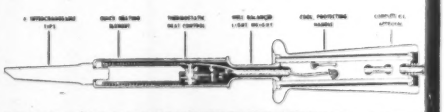
Stabilized Rectifier for Telegraph Supply

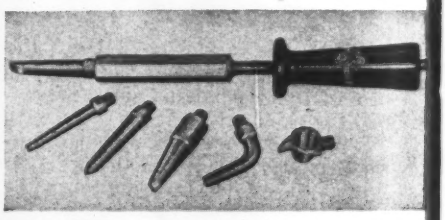
New series of "TRX" stabilized rectifier units have dynamic voltage regulation characteristic such that the load current may be varied between zero and maximum at any demand frequency, with negligible variation in terminal voltage. This is important in telegraph and similar service (Teleregister, teletypewriters, etc.) where rapidly fluctuating load demand may vary from zero to maximum in a few milliseconds. Good dynamic voltage regulation is therefore necessary in order to prevent failure of receiving relays resulting from momentarily low circuit potentials. The new "TRX" circuit (patent applied for) compensates also for normal variations in a-c. supply voltage to the rectifier unit. Other features of "TRX" stabilized rectifier units include: (1) completely non-resonant filter; (2) optional connection to 115- or 230-volt 50/60 cycle a-c. supply; (3) optional output ranges 110-120, 150-160 volts; (4) circuit breaker switch protection on a-c. side; (5) voltmeter, ammeter, and supervising lamps; (6) construction for mounting in standard 19" panel cabinets; (7) models for 1-, 2-, 4- and 7-amp. capacity.—*W. Green Electric Co., Inc., 130 Cedar Street, New York City.*



Thermostatic Soldering Iron

New "Kwikheat" thermostatic soldering iron has a built-in thermostatic heat control which prevents overheating and therefore increases service life.

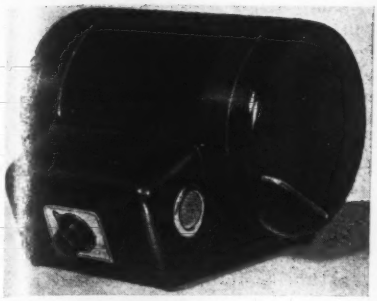




Tips need less retinning because they are never overheated. Six different tip-styles, made of corrosion-resistant copper alloy, can be interchanged. Iron has a 225-watt heating element which heats it in 90 seconds, a hard-chrome-plated steel shaft, molded plastic handle, a 6-ft. flexible cord of 3000-cycle HPD, and a rubber molded plug. New iron has approval of Underwriters Laboratories. — *Sound Equipment Corp. of Calif., 3901 San Fernando Rd., Glendale 4, Calif.*

Photo Transparency Viewer

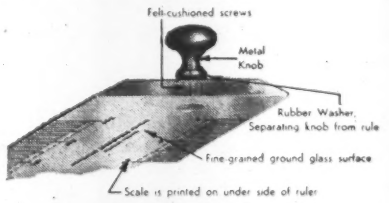
New "Copeland Super-Viewer" magnifies with exceptional clarity 2" × 2" and 3¼ × 4¼" photographic transparencies, is said to incorporate revolutionary features. Images seen with this viewer are completely free from color fringes (chromatic aberration). Instrument provides images which observers describe as a three-dimensional effect. It is supplied with two slide carriers: one to hold 2 × 2" slides, the other 3¼ × 4¼" slides. Transparencies in other sizes can be viewed by masking and mounting between cover glasses of the above sizes. Rotating cylinder housing the 8½" wide optical system permits adjustment of viewing angle up or down. A rheostat permits variable lig t-



ing and acts as an "on-off" switch. Optical system is not lens-type: is composed entirely of surface-coated mirrors, is said to "make possible for the first time a combination of high magnification and large field of view." Lighting system consists of a 25-watt lamp backed by white reflectors, in a ventilated housing. — *Barnett Optical Laboratories, Chicago 26, Illinois.*

Precision Layout Scale

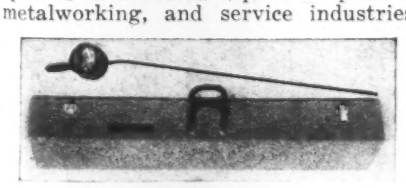
New layout scale carries divisions of 0.001" at 50× magnification ruled on the under side of the selected plate glass of which it is formed. All meas-


Felt-cushioned screws
Metal Knob
Rubber Washer, Separating knob from rule
Fine-grained ground glass surface
Scale is printed on under side of ruler

urements are therefore made when the ruled lines of the scale are in actual contact with the work, permitting accurate readings even though viewed from different angles. There are two bevels at each edge: larger bevel at top through which rulings are viewed is at such an angle that it projects lines on scale to extreme edge, thus making exact measurements possible, even though there is a tiny bevel along the lower edge which eliminates danger of blotting ruled ink lines. The straight edges of these rules have been lapped and polished so that the pencil or pen glides along them without detectable friction.—*Engineers Specialties Div. The Universal Engraving and Colorplate Co., Inc., 980 Collicott St., Buffalo 8, N. Y.*

Hand Pyrometer

New portable hand pyrometer is for measurement of temperatures of atmospheres and heated liquids in process, metalworking, and service industries.



Already in use by the Navy for measuring the temperature of zinc pots aboard aircraft carriers, new pyrometer is said to provide an easy, accurate method of temperature determination: it is simply inserted into the liquid or atmosphere to be measured and the temperature read from the scale. New pyrometer is so constructed that no

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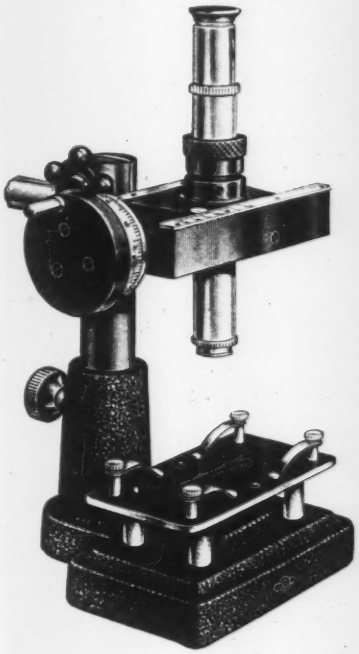

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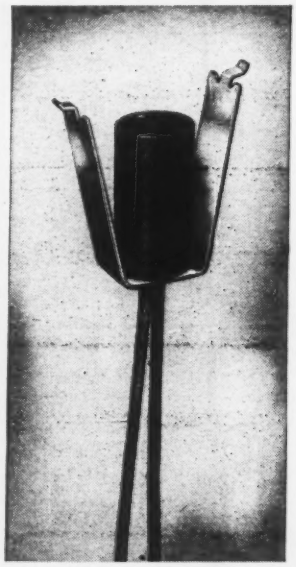

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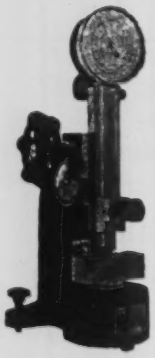

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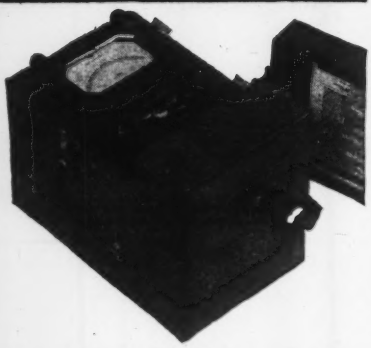

Test Potential to 600 Volts DC. Ranges to 1000 megohms with two or three additional ohm ranges in each instrument. Long mirror scales, hand drawn, individually calibrated, with more scale divisions for superior readability and split hair accuracy. Automatically decreasing test potential protects equipment of low resistance value.

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WRITE FOR BULLETIN 445

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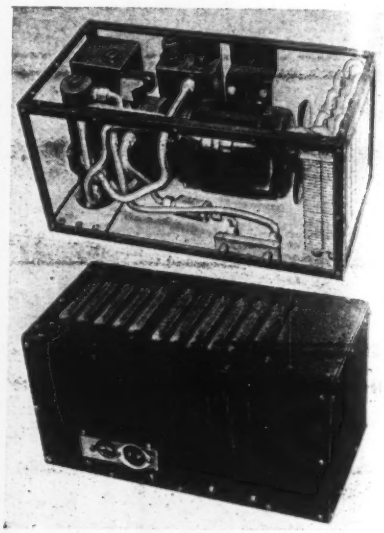
parts will work loose in service and is built to withstand without failure the normal strains of jars, vibrations, and other conditions incident to shipping, storage, and service. Parts are interchangeable to prolong service life and facilitate repair. — *Roller-Smith Co., Bethlehem, Penna.*

Heat-dissipating Units

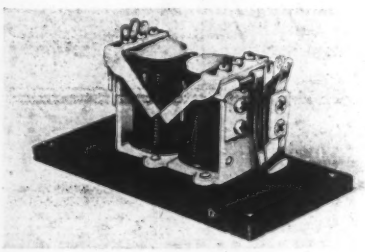
New heat dissipating units for use in x-ray tubes, induction heating, television, radar, short-wave radio, etc., were originally designed for Armed Forces,



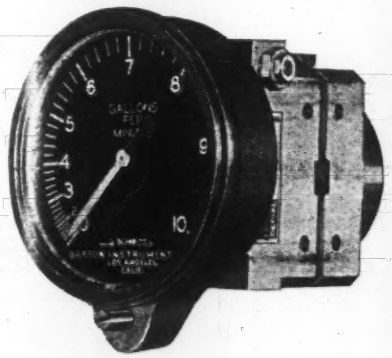
are furnished complete with thermostat control, thermostatic valves and flow switch. Unit shown will dissipate up to 1200 watts with a constant controlled temperature, irrespective of surrounding temperature, within 2°C. This 16" × 7½" × 7½" unit is available in steel, bronze or aluminum. Larger models (up to 5000 watts) and smaller models can be supplied. In most cases where new equipment is being designed which requires heat dissipation or controlled temperature, a specially engineered unit will meet requirements.— *Eastern Engineering Co., New Haven, Conn.*

Latching Relay

New small "Aerotrol" latching relay combines two standard "Aerotrol 400 series" relays, with an interlocking armature. This design makes it possible to combine any two "Aerotrols" of similar or different types into a latching relay. New relay is in either single or double pile-ups and with all standard spring pile-up formations and combinations. Latching "Aerotrols" can be supplied for either a-c. or d-c. oper-



MODEL 163
INDICATOR
Differential Pressure Type



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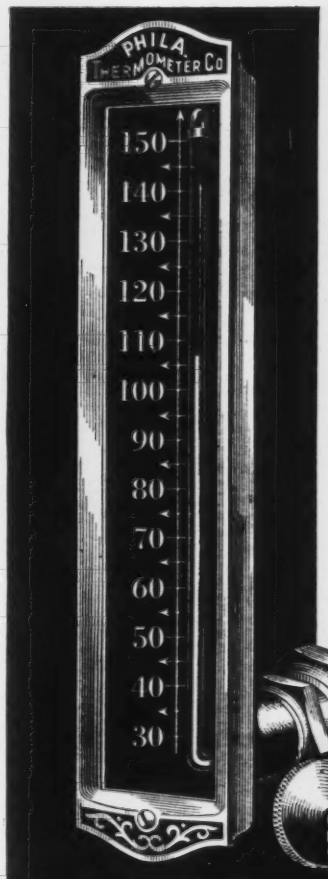

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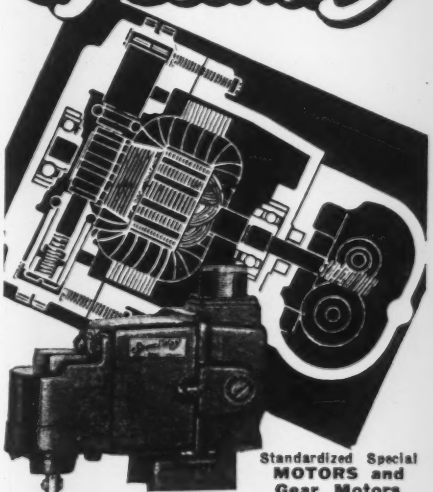

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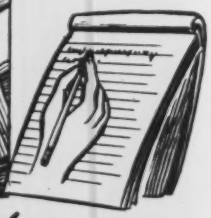

That means he is using a
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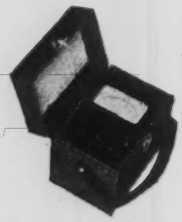
INSULATION RESISTANCE TESTER



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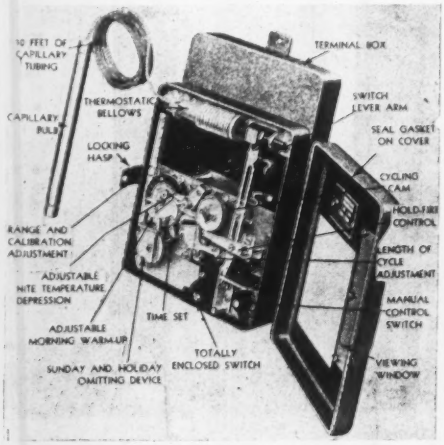
tion with maximum voltage of 125v. d-c. or 120v., 60 cycle a-c. Dimensions: height, 1 9/16", length, 2 7/8", width, 1 5/16". —*Magnetronic Div., Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.*

Temperature Control System for Buildings

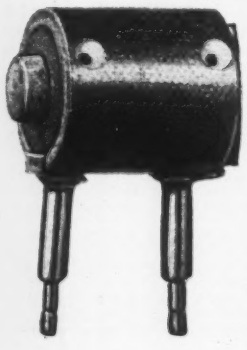
New "Econostat" regulates heating system of a building directly from the outdoor temperature by varying the "heat on" periods. Thus, heat supplied



to building is proportional to heat loss from building and not dependent on temperature in any particular room. A wide range of adjustments permits instrument to be adapted to operating condition of individual installation. Length of time for each cycle, operating range, calibration, amount of night temperature depression, as well as morning warm-up, are all adjustable. Result is said to be a simple, compact and dependable temperature control system which can be easily installed and adjusted to assure economical fuel consumption. "Econostat" is adaptable to steam or hot water heating systems in either new or existing buildings. It can be used to control motor-operated valves, stokers, and gas or oil burners. — *Barber-Colman Co., Rockford, Illinois.*

Plug-in Switches

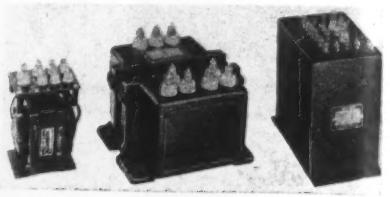
A new switch which is instantly renewable, similarly to a fuse, is designated as a plug-in type, in that there are two brass plugs which fit into sockets. Switch is furnished complete with plug and socket. It is a non-snap type. However, makers announce that they are now arranging to furnish their



entire line of switches, which run from midget size to some capable of taking 50 amps. at 110 volts a.c., with this renewable feature. These are full snap switches having double break contacts and operating at speeds from 1/10th to 1/60th of a second.—*Robert Hetherington & Sons, Inc., Sharon Hill, Penna.*

Iron-core Magnetic Components

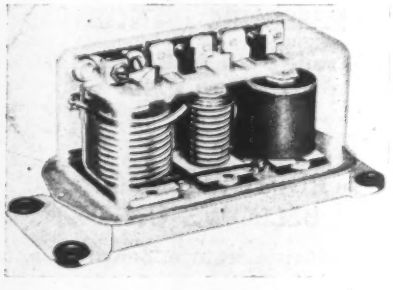
New iron core magnetic components are designed with power ratings ranging from milliwatts to kilowatts, and are constructed in open frame, semi-



enclosed, enclosed and hermetically sealed types; and with various terminal types, including standard nut-fasteners and solder-type binding posts with porcelain bases. Hermetically sealed units utilize either compression bushings on porcelain bases, or glass-to-metal fusion seals in one piece covers, and it is claimed that they can withstand successive immersion in ice-water after hot tin dip. Applications include plate and filament supplies, audio-frequency and modulation transformers, power transformers and reactors.—*Federal Telephone and Radio Corp., 200 Mount Pleasant Ave., Newark, N. J.*

Heavy-duty Voltage Regulators for Low-voltage D-c. Generators

New 3-unit vibrating type heavy-duty voltage regulators for low-voltage d-c. generator application are especially suitable for stationary or mobile gas



engine- or motor-driven generators. All three units (reverse current relay, voltage control, and current limiter) are designed to work in any position and withstand external vibration and shock normally encountered in mobile apparatus. Complete assembly is sealed in a dust-tight water-proof gasketed drawn steel enclosure. New regulators are available in maximum capacities of 30 amperes at 6 to 32 volts and 45 amperes at 6 to 12 volts d-c. Maximum field current rating: 3 amperes at 6 volts; 0.5 amperes at 32 volts d-c. Approx. dimensions: width, 7¾"; depth, 4"; height, 3½". Average weight, 3.25 lbs. Because such voltage regulators must be calibrated as to settings and resistance values to match generator

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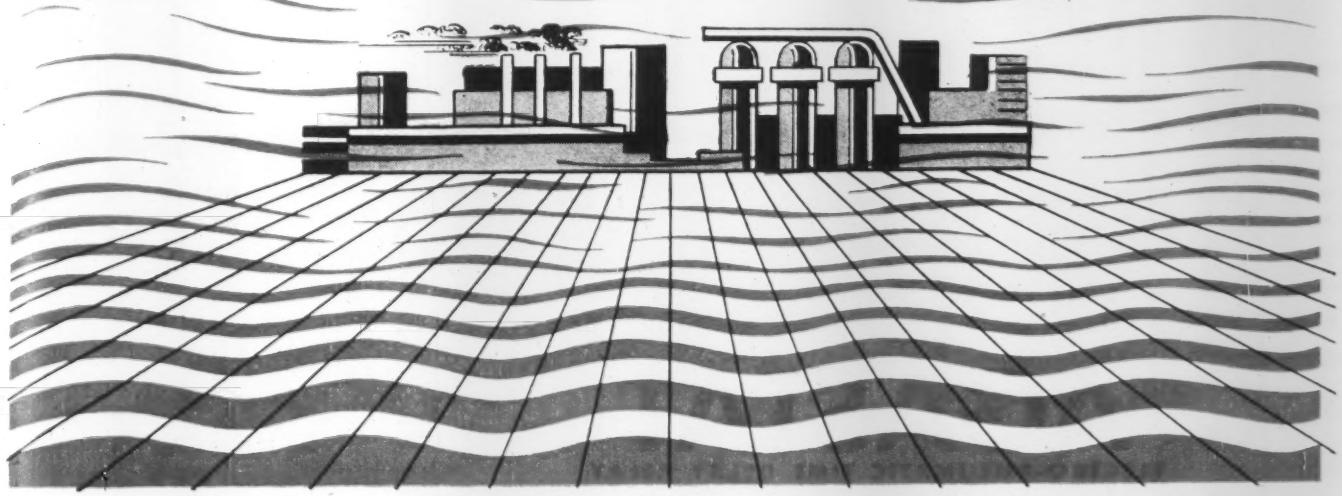

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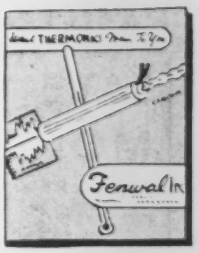

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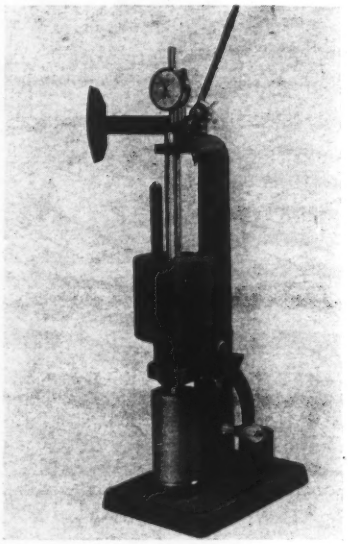
specifications, it is necessary to consult manufacturer's engineering department, giving complete characteristics of generators.—*R-B-M Mfg. Co., (division of Essex Wire Corp.), Logansport, Indiana.*

Sand Rammer

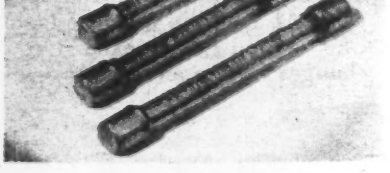
New sand rammer built in accordance with A.F.A. specifications is used to obtain rammed sand specimen of 2″ × 2″ dimension. It incorporates the



following features: longer weight raising cam bearing; take-up on weight raising cam bearing; lever cam for raising rammer-plunger-weight assembly during loading and unloading cycle; flowability indicator mounted on top to improve visibility of dial, cleanliness of indicator and the life of indicator by reducing shock; flowability indicator automatically moves to inoperative position on raising plunger assembly. Sand Rammer illustrated is equipped for moisture determination and flowability determination.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.*

Sealed-in-glass Selenium Rectifiers

New high-voltage selenium rectifier stacks, hermetically sealed in glass are no larger around than a fountain pen and constructed like a cartridge fuse.



Electrical connection is made through heavy silver-plated ferrules at each end of glass tube. Ferrule size permits mounting in 30-amp. fuse clips unpolarized or polarized by addition of simple member to fuse clip assembly. New rectifiers are especially designed for operation in high ambient temper-

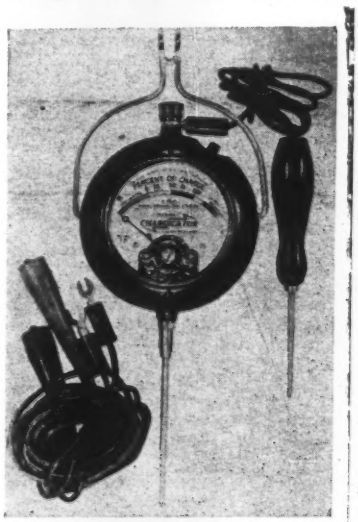
tur[illegible], are available in several tube leng[illegible]hs and in voltages up to 4000 volt[illegible] —*Federal Telephone & Radio Co[illegible], 67 Broad St., New York 4, N. Y.*

Power Supply

New Model H Porta-power instrument consists of a two-section filter, composed of three capacitors and two oversized iron chokes in the "A" supply and two capacitors and an oversized choke in the "B" supply to block out the hum in operating 4-, 5-, or 6-tube 1½ volt battery radios from 105-125 volt, 50-60 cycle lines. Circuit is designed for optimum voltage regulation and changes in line voltages. Provides for "A" supply 1.5v. at 200 ma., 1.35v. at 250 ma., 1.55v. at 300 ma., 1.35v. at 350 ma. and for "B" supply 90v. at 13 ma. 101v. at 8.5 ma.—*General Transformer Corp., 1250 W. Van Buren St., Chicago, Ill.*

Battery Condition Tester

New "Chargicator" indicates electrically the equivalent gravity of any lead-acid storage battery, regardless of size or voltage. It places no load on the



battery and battery need not be disturbed at time of reading. Instrument may be permanently connected to battery, or used as a portable tester. Probe type "Chargicator" illustrated gives instantaneous measurement of battery condition, shows what charging rate to use, indicates percentage of charge and charging danger and warns of destructive overcharging. Weak or defective cells are spotted before actual failure occurs and instrument may also be used as a check against future failure by using it in conjunction with a load test. Four-color-scale dial eliminates guess-work, is said to be "four times more accurate than conventional instruments." A size and type is available for every need. All models are sealed within molded acid-proof Bakelite cases and are not affected by weather or temperature. — *Hickok Electrical Instrument Co., 10519 Dupont Avenue, Cleveland 8, Ohio.*

INSPECTING MIDGET ELECTRONIC TUBES

with the **MICROSCOPE**

Small in size, but big in performance, electronic tubes like the one above have made possible camera-size radios, hearing aids that fit the palm of your hand, "walkie-talkies," and many other developments.

The originator of these tubes, Hytron Radio and Electronics Corporation, overcame control and inspection difficulties (spacing tolerances in some tubes are as small as .0008 in.) by extending the vision of their workers with Spencer Stereoscopic Microscopes.

Providing greatly enlarged, clearly defined, three-dimensional images, these microscopes offer advantages to all who must study small details. For descriptive literature write Dept. Z32.

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Instrument Societies

CHICAGO

The regular meeting of the Chicago Section of the Instrument Society of America was held November 5th at the Merchants and Manufacturers' Club in the Merchandise Mart and approximately 150 members and guests were present.

The speaker of the evening, P. A. Elfers, Vice President in charge of sales, Fisher Governor Company, selected as his subject, "Direct-actuated Pressure Regulators." Slides of the various types of regulators were shown and discussed by the speaker.

In his discussion of the operational principles of these various types of regulators, he pointed out the advantages as well as the limitations of each type. He classified direct-actuated regulators as, any type which did not require operating medium from an outside source; several examples were cited and the application of each given.

Following P. A. Elfer's presentation, an interesting question and answer period was held and, judging from the duration and active participation of this period, there was extreme interest in P. A. Elfer's subject.

—J. A. Riggs, *Technical Chairman*

INDIANAPOLIS

A group of Indianapolis instrument men held a meeting November 30th in the office of the Minneapolis Honeywell Regulator Co. in order to organize Indianapolis into an active Section of the Instrument Society of America. Mr. Sesson (a host) was named Chairman *pro tem*, Morris Underwood, temporary Secretary, and Montgomery, Vice-chairman.

Discussions pertaining to the date of meeting, place, committees, etc., took up the major part of the evening. A steering committee was chosen which consisted of the following: Chairman: Sisson (Minneapolis-Honeywell Regulator Co., also a member of the Kansas City Society); Vice Chairman: Montgomery (P. R. Mallory & Co.); Secretary: Morris Underwood (Indianapolis Power & Light Co.); Membership: Fox (Light Metals, also member of Wayne County Society); Rockwell (Thomas & Skinner); Keeler (Eli Lilly & Company).

Harvey Rockwell emphasized the importance of having good programs, speakers for all meetings, which led into the decision as to the next meeting. After deliberating as to a date that would not conflict with any other scheduled meetings of various other organizations it was decided to have the meeting December 6th at 7:30 p.m. at the Purdue University Extension, 902 N. Meridian St., Indianapolis. —H.W.H.

KANSAS CITY

At the November meeting the Kansas City Industrial Instrumentation Society, M. A. Enquist (Fluor Corp.), George Agin (Sheffield Steel), and Baker Manley (J. F. Pritchard) acted as tellers to count the votes cast for officers. The officers elected were as follows: *President:* Lester Johnson (Sinclair Refining); *Vice-President:* Robert Cook (Westinghouse Electric); *Secretary-Treasurer:* Oliver Boutros (Boutros Instrument Company).

Stan Furber (Minneapolis-Honeywell) presented a fine talk on "The Application of Instruments on a Typical Air Conditioning Fan System" as our basic lecture.

Our guest speaker, M. J. Boho, Assistant General Sales Manager of the Hagan Corp., presented an illustrated talk on "Multiple Fuel Firing Control." He began his lecture by giving us the basic theory of combustion and then explaining what multiple fuel firing was and why it was used. The illustrations and descriptions of the various controllers used, such as totalizing relays, ratio flow devices, etc., were interestingly educational and definitely enjoyed by all those present.

A motion was passed by the membership that our society should not take action on the Constitution of the Instrument Society of America until we had a copy of the by-laws under which this Society will function.

—W. A. Reichow, *President*

NEW JERSEY

The annual joint meeting of the New Jersey and the New York Sections of the I.S.A. was held November 13 in the Essex House in Newark. These joint sessions are always well attended and very interesting and we hope they can be continued indefinitely.

Our speaker, Mr. J. G. Berger, Consulting Engineer, enlightened us on the instrumentation in the small power plant. His illustrated talk stressed the economical possibilities with proper operation and showed clearly how proper instrumentation fits into the picture. He also stressed the degree of instrumentation necessary, and economically justifiable, for various size boiler units.

The meeting was well attended and a group of twenty constituted the delegation from our neighboring N. Y. Section.

—H. S. Close, *Secretary*

NEW ORLEANS

The New Orleans Instrument Society was organized November 28th at a meeting held in the St. Charles Hotel at 8:00 p.m.

The meeting was open to discussions and extemporaneous talks pertaining to the Society, plans and organizational problems. Those present participated in expressing their views on the subject of organizing. After considerable discussion it was decided to elect temporary officers. The following were elected: A. W. Chapman (Manager of Technical Operations Celotex Corp.) elected to serve as President for the balance of the year and W. H. Haney as temporary Secretary-Treasurer. The chairman announced that the next meeting would be held December 17th at 8:00 p.m. in the St. Charles Hotel, as decided.

—W. H. Haney, *Sec'y-Treas.*

ST. LOUIS

The St. Louis Society for Instrumentation held its regular November meeting at the DeSoto Hotel in St. Louis on Monday, Nov. 19th, at which time the speaker, Ray Wassell of the Airpath Instrument Co. of St. Louis gave a very interesting description of various aircraft instruments such as: Air Speed, Rate-of-climb, Sensitive Altimeter, Manifold Pressure, Turn-and-bank, Gyro Compass and Magnetic Compass. He discussed the value and limitations of each instrument and the construction features of a few. He pointed out that the Gyro Compass, while steadier in flight than the Magnetic Compass, will gradually develop an error due to precession of the gyro and must therefore be re-set at short intervals by means of the Magnetic Compass. It was concluded that a magnetic compass is a necessity in the plane, in addition to the Gyro Compass. The great value of the Gyro Compass in keeping on the beam when coming in for a landing was stressed, as well as the method of compensating the Magnetic Compass for the metal in the plane by the adjustment of permanent magnets built in the instrument.

Having been a pilot in World War I, Wassell's remarks and descriptions of aircraft instruments were given in the light of practical information for the men that use them today.

—H. E. Zeffren, *Secretary*

Northern Indiana Society for Measurement and Control
EDUCATION-FRATERNITY-DEMOCRACY

The Northern Indiana Section of the Instrument Society of America held its meeting at the Lake Hotel in Gary, Ind., Nov. 16th.

Following the dinner, the meeting was turned over to a delegation from Brown Instrument Company headed by Charlie Sharp and Earl Bush. This delegation came prepared to answer any questions that those present asked.

Before the meeting, each person was given a card upon which he was requested to write down any questions he wished to have answered or discussed by the delegation. After the dinner, the cards were given to William Hitt, Program Chairman, who read them individually to the group. The delegation considered each question; then gave an answer and explanation. Considerable interest was created and a number of discussions were started.

This educational, as well as enlightening, meeting was concluded with a report from Gene Bainbridge, our representative at the meeting of the Instrument Society of America held at Pittsburgh.

—Paul Keefer,
Member of Publicity Committee

PHILADELPHIA

Dr. C. O. Fairchild's discussion of the role of the Galvanometer in Recorders highlighted the November meeting of the Philadelphia Section.

Dr. Fairchild, Research Director of the C. J. Tagliabue Company, explained in terms familiar to the layman the design of the present-day mirror-type galvanometer, its features—pointerless, having a low moment of inertia, permitting a lower torque—greater sensitivity, a reflected light beam doubling the angle of the coil reflection summed up greater accuracy.

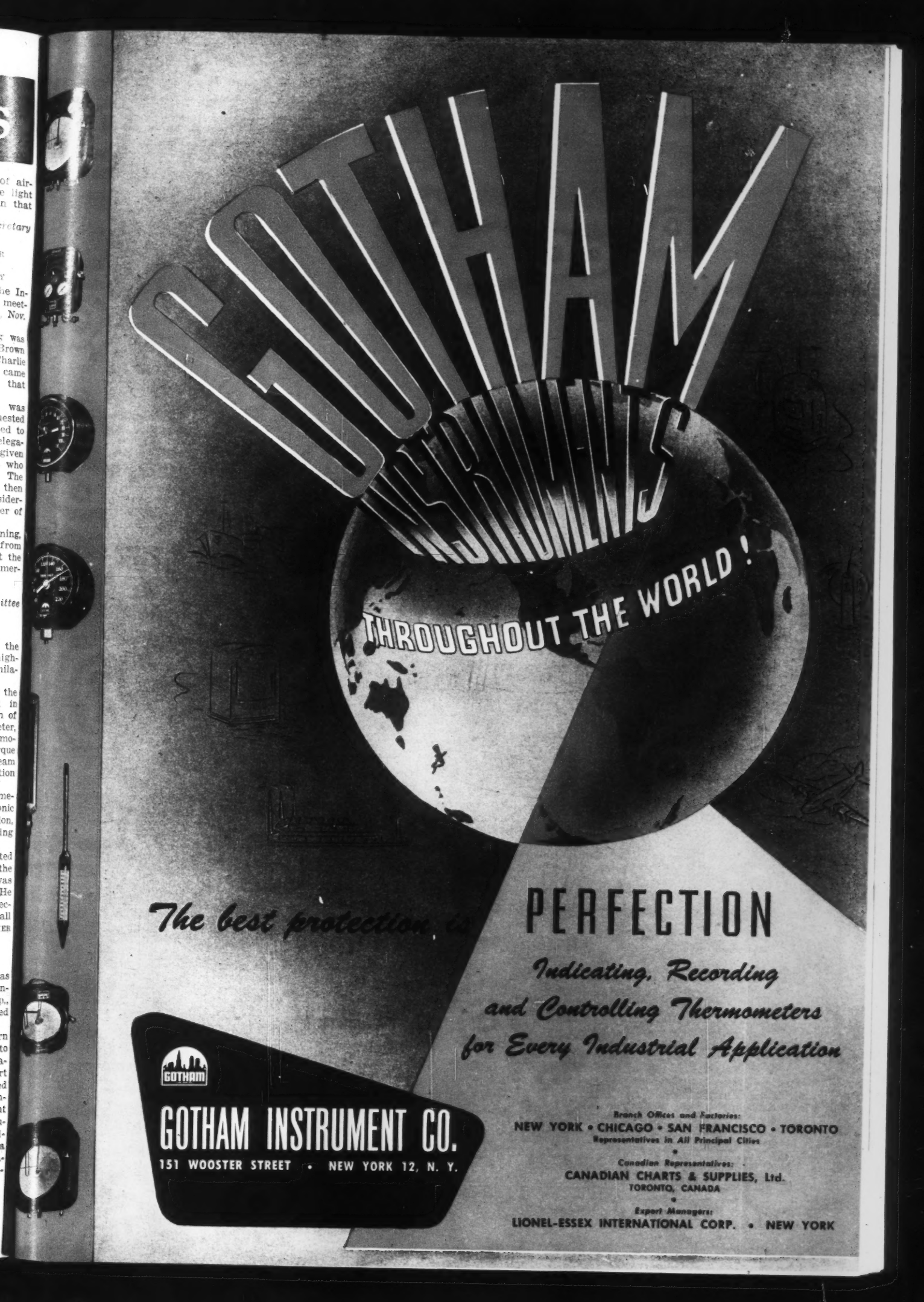
He also dwelt on the history of the mechanical galvanometer, and the electronic pyrometer, along with slides. In conclusion, Dr. Fairchild demonstrated an Indicating Potentiometer Controller.

Our Chairman, T. R. Newcomb, presented the revised draft of the constitution of the Instrument Society of America, and it was accepted unanimously by the members. He also mentioned the coming December election of new officers, and requested that all be present. —George Hammer

SOUTHWEST TEXAS

The first meeting of the South Texas Instrument Society was held in the conference room of the Southern Alkali Corp., Corpus Christi. Lynch (S. A. C.) presided as temporary chairman.

J. C. Leppart, on behalf of the Southern Alkali Corporation, extended a welcome to the group and stated that "the organization is certainly worthy of all the support which can be given it, and to rest assured that you have ours." In praising instrumentation, Leppart cited a visit through a plant in Baltimore, Maryland, where the instrumentation was such that one man practically operated the plant. He expressed a desire to visit again when the organizational stages have been ironed out and con-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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta, Georgia	**Georgia Society for Measurement & Control**	**Robert E. Geminert, P.O. Box 1714, Atlanta**		**Blue Flame Room, Atlanta Gas Light Co.**		
Baltimore, Maryland	**Baltimore Industrial Instrumentation Society**	**F. Ragan, Fuel Div., Beth Steel, Sparrows Pt., Md.**		**Engineers Club, 6 W. Fayette St., Balto.**		
Charleston, W. Va.	Charleston Instrument Society	M. B. Lorig, 1506 Virginia St., Charleston 1	Jan. 7(A)	Kanawha Hotel	Combustion Control	T. A. Cohen, Wheelco Co.
			Feb. 4(A)		Telemetering	P. A. Borden, Bristol Co.
			Mar. 4(A)		Boiler Control	M. J. Boho, Hagan Corp.
			Apr. 1(A)		Control Valves	Bruce A. Irwin, Mason-Neilan Co.
			May 6(A)		Pneumatic Transmission and Control	W. B. Heinze, Cochrane Corp.
Chicago, Ill.	**Chicago Section, I. S. A.**	**A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago**	Jan. 7(B)	(To be announced)	Displacement Meters	E. W. Jacobson, Gulf Research
			Feb. 4(B)	(To be announced)	Instrumentation in Plant Design	(To be announced)
			Mar. 4(B)	(To be announced)	Application of Valves in Automatic Control	C. E. Mason, Bristol Co.
			Apr. 1(B)	(To be announced)	New Optical Tools	J. W. Forrest, Bausch & Lomb
			May 6(B)	(To be announced)	New Electronic Measuring Instruments	W. Mikelson, General Electric
Cleveland, Ohio	**Cleveland Instrumentation Society**	**A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3**	Jan. 23(B)	Cleveland Engineering Society, E. 19th St. off Prospect Ave.		D. O. Komich Trimount Instrument Co.
Detroit, Mich.	**Instrument Society of Detroit**	**Cliff Sackett, Chrysler Eng'g 12800 Oakland Ave. Det't**				
Florence, Alabama	Muscle Shoals Instrument Society	J. W. Moffett, 323 E. Mobile St., Florence				
Fort Worth, Texas	**Fort Worth Electronics Club**	**Ralph Ely, 1116 E. Arlington, Fort Worth**		**Texas Hotel, Fort Worth**		
Gulf Coast (Texas)	**Gulf Coast Section, I. S. A.**	**C. D. Holt, 2509 Lake Shore Dr., Port Arthur, Texas**				
Hartford, Conn.	**Hartford Society for Measurement & Control**	**Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.**	Dec. 18(B)	Hotel Taft, New Haven Parlor "B"	Testing Electrical Instruments	Fred W. Lingel Triplett Electrical Inst. Co
			Jan. 22(B)	Bond Hotel	Practical Inspection of Metals	Dave Nemser, International Nickel Co.
			Feb. 19(B)	Bond Hotel	Use of Air in Gaging	R. Y. Moss, Sheffield Corp.
			Mar. 19(B)	Bond Hotel	Electron Microscope	Dr. R. B. Barnes, C. J. Burton, Amer. Cyanamid
			Apr. 16(B)	Bond Hotel	Comparison of Materials for Gages	H. O. Richter, W. R. Moore, Norton Co.
			May 21(B)	Bond Hotel	(Annual Business Meeting)	
Kansas City, Missouri	**KC Industrial Instrumentation Society**	**Gordon H. Burke, 1527 Broadway, Kansas City, Mo.**	Dec. 18(B)	Blue Bird Caf.	Sound Film "Theory & Application of Elec. Inst."	Westinghouse Mfg. Co.
Los Angeles, Calif.	**California Instrument Society**	**M. D. Pugh, 541 South Spring St., Los Angeles, Calif.**		**Melody Lane, Los Angeles**		
Newark, N. J.	Society for Measurement & Control (New Jersey)	H. S. Close, 831 Dixie Lane, **Plainfield, N. J.**	Jan. 8(B)	Essex House	Characteristics of Flow Metering Equipment	L. K. Spink, Foxboro Co.
New Orleans, La.	New Orleans Instrument Society.	W. H. Haney, 1016 Esplanade Ave., New Orleans, La.	Dec. 17(D)	St. Charles Hotel	(To be announced)	
New York, N. Y.	**New York Society for Measurement & Control**	**H. L. Hildenbrand, 206-07 33d Ave., Bayside, L.I., N.Y.**	Dec. 19(B)	Faculty Club 400 W. 117th St.	Seven Basic Methods of Flow Control	Donald P. Eckman, Brown Inst. Company
N. Indiana	Northern Indiana Section, I. S. A.	**C. P. Haynes, Red River Oil Refinery, 935 — 177th Place, Hammond, Ind.**	Dec. 14(C)	**Ultra Modern Dining Rm. Indianapolis Blvd., E. Chicago, Ill.**	What, Where, Why & How of Draft	C. B. Hovland, L. W. Murphy Co.
			Jan. ?(B)	Lake Hotel, 740 Washington St., Gary	Application of Hydraulic Control	D. Pray, Askania Regulator Co.
Philadelphia, Pa.	**Philadelphia Society for Instrumentation**	**G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia**	Dec. 19(B)	**Broadwood Hotel, Broad & Wood Sts.**	**Maintenance Problems in Refinery Inst'tion**	Edward Grace, Albert Krieg
Pittsburgh, Pa.	Pittsburgh Section, I.S.A.	**L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.**	Dec. 17(B)	Roosevelt Hotel	Diaphragm Motor Valves and Components	L. E. Eige, Fisher Governor Co.
			Jan. 28(B)	Roosevelt Hotel	Captured Gyro Inst's	Walter T. Buhl, Jack & Heintz
			Feb. 25(B)	Roosevelt Hotel	Fractionating Column Control	Lyman H. Allen, Jr. Amer. Viscose Corp.
			Mar. 25(B)	Roosevelt Hotel	Inst. Maintenance in Oil Refinery	M. H. White, Atlantic Ref. Co.
			Apr. 22(B)	Roosevelt Hotel	Control Valve Characteristics	R. Rockwell, Mason-Neilan Co.
			May 27(B)	Roosevelt Hotel	Fractional H-p. Electric Motors	C. G. Veinott, Westinghouse Elec. Co
St. Louis, Mo.	**St. Louis Society for Instrumentation**	**Gus Holubeck, Union Electric Co., Venice, Ill.**		DeSoto Hotel, 11th & Locust Sts.		
Southwest Texas	South Texas Instrument Society	Homer C. Givens, La Gloria Corp., Falfurrias, Tex.				
Sarnia, Ont. Canada	Sarnia Instrument Association	K. Williamson, 168 Cobden St., Sarnia, Ont., Can.				
Kingsport, Tenn.	**Tennessee Section, I. S. A.**	**C. F. Palmer, 2924 J. C. Hwy., Kingsport**		Kingsport Inn		
Toronto, Canada	Canadian Society for Measurement & Control	**T. C. Agnew, Minneapolis-Honeywell Reg. Co.**		Chez Paree Restaurant, 220 Bloor St., W.		
Washington, D. C.	Instrument Society of Washington	**W. A. Wildhack, National Bureau of Standards, Wash'n**	Jan. 22(B)	All Souls Church, 16th & Harvard St. N.W.	(To be announced)	
Whiting, Indiana	**Whiting Instrument Men's Guild**	**Lloyd Clouse, 7344 Dante Ave., Chicago 19, Illinois**				
Wyandotte, Mich.	**Instrument Society of Wayne County**	**Wilson Fox, 33 Chestnut St., Wyandotte, Mich.**		Monsanto Auditorium, Trenton, Mich.		

(A) Meeting at 7:30, no dinner **(B) Dinner at 6:30, meeting at 8** **(C) Dinner at 7, meeting at 8** **(D) Meeting at 8, no dinner**

cluded his remarks by wishing the organization success.

After the introductions, at which time each man stated his name and the firm with whom he was associated, Lynch briefly explained the purpose of the organization and brought out that it was open to all interested in Instrumentation.

F. [illegible] Pratt (Gasoline Plant Construction) was elected temporary president to serve for the remainder of the year and other officers were appointed as follows: *Secretary:* Homer C. Givens (La Gloria Corp.) *Treasurer:* V. J. Brunson (Sinclair Refg. Co.); *Executive Committee:* H. P. Cheatham (Southwestern Oil and Refg.); W. A. Rock (Foxboro Co.), J. B. Young (La Gloria Corp.). *Program Committee:* L. J. Lynch (Southern Alkali Corp), W. A. Rock (Foxboro Co.), J. P. Nielson (La Gloria Corp.) and Louis Needhan (Public School System of Corpus Christi).

"South Texas Instrument Society" was the name unanimously chosen and the second Tuesday of each month was decided as the regular meeting date. It was also decided that the responsibility of choosing the program, date, time, etc., was to be left in the hands of the Program Committee, who would inform the Secretary of their decisions and he in turn would notify the members.

The meeting adjourned at 10 p.m. after the group expressed their appreciation to Lynch and Bates (Humble Oil) for their efforts in getting the organization started and after it was decided to pass the by-laws at the next meeting.

—H. C. GIVENS, *Secretary*

WASHINGTON

At the November meeting of the Instrument Society of Washington, held on Nov. 20 in the Interior Department Auditorium, Alvin G. McNish of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, discussed the "Design and Testing of Precision Magnetic Compasses." A number of compasses developed during the war by a group under his direction were displayed. A film on the Gyrosyn Compass was shown through the courtesy of the Sperry Gyroscope Company.

Short reports were presented on the actions taken at the ISA meeting and on the conference held in Pittsburgh in October.

—W. A. WILDHACK, *Corresponding Secretary*

WYANDOTTE

The Instrument Society of Wayne County met November 26 at the Monsanto Plant, in Trenton, at which time a condensed War Training Course on Electrical Measuring Instruments was presented by Teetsell and Ross (Westinghouse Central Division). Slides and recordings were used and added much interest to the well-attended meeting.

At the conclusion of the meeting one of our visitors, a discharged aviation instrument man, gave us the pleasure of seeing some salvaged German aviation instruments.—JOHN MACPHERSON, *Vice President*

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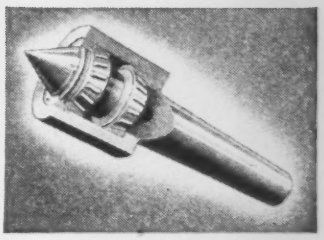

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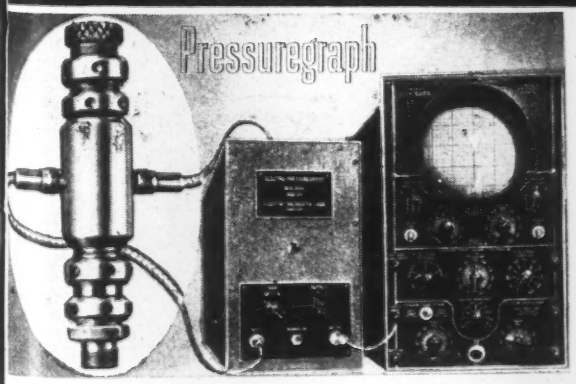

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on page 949.

M-309 **Dials, Panels and Nameplates.** 8-page 8½" × 11" Bulletin 8145 describes and illustrates maker's facilities for manufacturing a variety of metal products, many of which are illustrated, including dials, data plates, nameplates, and panels for instruments and electric and electronic equipment, produced by lithography, etching and colorplating. L. F. Grammes & Sons, Inc., 379 Union St., Allentown, Pa.

M-310 **Cohesion Tester.** 4-page 6" × 9" bulletin describes and diagrams the Duplan cohesion tester for the testing of rayon and raw silk. Complete instructions are given for operating and an illustrated cohesion report of results is duplicated. This machine will test the effectiveness of theslashing solution or Rayon by testing the cohesion of the sizes viscose and acetate before the warp reaches the loom and will also record whether raw silk has the necessary cohesion for good performance as warp material. Geier and Bluhm, Inc., Troy, N. Y.

M-311 **Hydraulic Pressure Gages.** Single-sheet 8½" × 11" bulletin describes and pictures the piston-type hydraulic-pressure gage. Claimed features of the valve are accuracy with tempered precision springs, self-sealing packing, pulsation damping piston, luminescent scale figures and pointer, etc. Mansfield & Green, 4601 Euclid Ave., Cleveland 3, Ohio.

M-312 **Students' Potentiometer and Accessories.** 16-page 8½" × 11" Catalog No. 50B(1) is for teachers and technicians who are selecting scientific equipment to prepare their classrooms and laboratories to meet the next few years' demands. Designed for teaching, the instrument embodies the potentiometer principle in its simplest form. The catalog describes its construction features and simple design: its additional low range, for use with thermocouples; its terminal posts and end coils for Wheatstone bridge applications. Illustrated, described and listed on separate pages are the accessories used withthis instrument in its five most general applications: voltmeter and ammeter calibration, temperature, pH and electrolytic conductivity measurements. A brief description of the potentiometer principle is also included. Leeds and Northrup Co., 4907 Stenton Av., Philadelphia 44, Pa.

M-313 **Gage Blocks and Accessories.** 36-page 8½" × 11" Catalog No. 17 pictures and describes three basic uses of gage blocks: as master laboratory standards for control of measurements in precision manufacturing operations; as actual working instruments of measurements in tool room and design work and for the adjustment of production machinery; and for periodic checking of inspection gages at the benches. Many sets of blocks are shown, described and priced and numerous applications are pictured. Complete instructions are also given for care and handling of blocks. Ford Motor Co., Johansson Div., Dearborn, Mich.

M-314 **Nomograph for Steam.** 1-page 11" × 17" nomograph for determining correct rotameter size for steam measurement is a valuable guide to rotameter selection. Fischer & Porter Co., 923 South County Line Road, Hatboro, Pa.

M-315 **Open Channel Meters.** 12-page 8½" × 11" Bulletin No. 62 features open channel meters for sewage, industrial waste, sludge, water supply and irrigation and liquids with solids in suspension. Meters described are of both direct mechanical and electric telemetering types. A wide selection of registers is illustrated. Alternate methods of mounting registers on wall, panel and pedestal are shown. All types of registers are said to be suitable for use with flumes, weirs and atmospheric discharge nozzles. Bailey Meter Co., Cleveland 10, Ohio.

M-316 **Feed Water Regulators.** 8-page 8½" × 11" Bulletin No. 83-C entitled "Bailey Thermo-Hydraulic Feed Water Regulators" describes and illustrates improved designs of thermo-hydraulic generators and bellows-operated feed water regulator valves, suitable for feed lines from ¾" to 6". A full-page colored schematic illustration demonstrates the thermo-hydraulic principle. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

M-317 **"Electronic, Pneumatic, Mechanical Instrumentation."** 32-page 8½" × 11" July-August issue of this house organ (designated as Vol. 1, No. 5) contains the following articles: (1) New open hearth furnace at Homestead, Pa.; (2) Aviation advancements speeded by ElectroniK instruments at Wright Field, (3) Industrial use of radiation pyrometers under nonblackbody conditions, (4) Spectrophotometric automatic chemical analysis, (5) Open-hearth furnace pressure control system, (6) Instrumentation in contact sulphuric acid plants, (7) Temperature control of pickling tanks, (8) Temperature control systems for dual fired galvanizing kettles, (9) Temperature control of traveling plate ovens, (10) The absolute pressure gage, (11) Instrumentation of sausage manufacture, (12) "Tuning" a pneumatic control to the process. The Brown Instrument Co., Wayne and Roberts Aves., Philadelphia 44, Pa.

M-318 **"Instrument Manufacturing and Service Facilities."** 18-page 6" × 9" booklet describes, for both old clients and prospective new ones, the complete facilities now available for manufacturing and repair service. The shop is described as being well-equipped with a diversified group of machine tools, used by men who know them well and can develop and manufacture special-purpose electrical and mechanical instruments or their component parts, and custom-built laboratory apparatus and testing equipment. Nilsson Electrical Laboratory, Inc., 103 Lafayette St., New York 13, N. Y.

M-319 **Measurement of Resistance to Earth of Man-made Grounds.** 8-page 8½" × 11" Bulletin 104 describes ground resistance testing and relates how problems of conditions generally encountered are dealt with. The "Vibroground" was developed for the purpose and provide dependable measurements irrespective of earth resistance of auxiliary probe leads. It is unaffected by stray earth currents from d-c. or commercial frequency a-c. sources. Associated Research Inc., 221 S. Green St., Chicago 7, Ill.

M-320 **"Uses Unlimited."** 2-page 8½" × 11" issue of this house organ designated as Vol. 1, No. 3) devoted to switch gaging, features an illustrated article: "The mica gage accurately checks 3600 pieces per hour." Illustrated are various practical uses of the micro switch, such as double-action floating double-thickness detector, film notch detector, positioning safety switch, tension control, bimetal thermostat, sorting gage, sequence timer, weight control, metal-clad foot switch, etc. Micro Switch, Freeport, Ill.

M-321 **"Rotary Kiln Operation Improved Through Instrumentation."** 22-page 8½" × 11" Catalog N-00-664 (1) presents a complete line of instruments for measuring or controlling various kiln temperatures, for automatically controlling draft and for continuously measuring kiln speed. Applied singly or in combination, these instruments are said to provide uniformity of output, cut down temperature swings, reduce fuel costs and protect kiln linings; and to be applicable to any rotary kiln. A two-page schematic diagram of a typical kiln shows the various points to which instrumentation is being applied. Numerous pictures of the equipment in actual operation are also shown. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

M-322 **"Magni-Ray."** 4-page 8½" × 11" bulletin describes and pictures an instrument for enlarging any object in every detail, in true perspective, under light so intense that it is in itself practically as effective as another degree of magnification. Sketches of application are shown for the machinist, toolmaker, gunsmith, engraver, dentist, etc. Magnifier may also be used for textile, machine product and plastic inspection and for many other uses in factory, shop and home. George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.

M-323 **"Electrical Testing Made Easy."** 8-page 3½" × 6" folder describes and pictures an all-purpose electric circuit tester for indicating voltages from 90 volts d-c and 60 volts a.c. to 500 volts a.c. or d-c. It is especially valuable for the higher voltages, and also for circuits of very low amperages. The G-E neon lamp glows in varying intensities indicating different conditions in the circuit, and does not glow on dead lines. Immediate visual indication is given of circuit continuity, kind of current, approximate voltage, electrical discharges, etc. Amerline, 175 North Honore St., Chicago, Ill.

M-324 **"The Amazing Electron."** 34-page 5½" × 8½" booklet is intended to bring within the grasp of everyone the basic facts about electronics. The headings are: Something about atoms; What electronics is; What makes electric current flow; Thompson discovered electrons; The laws of the electrons; What an electron tube is; What electron tubes do; All tubes have these things in common: A source; The Edison effect; Enter the grid; The terminals; Radio tubes; Electromagnetic waves; How your radio works; What modulation is; A-M; What is F-M; Electronics is at war; Television: The camera tube; The receiver tube; X-ray tubes; Electron gun; The phototube; Electronics on the swing shift; and Here's the last word. Electronic Corp. of America, 18th St., New York 11, N. Y.

M-325 **Lubricant for Precision Surfaces.** 6-page 3½" × 7" folder describes the properties of "Gage Lube" as increasing gage life by 3 to 10 times; as a non-gumming, non-loading, practically dimensionless, rust-inhibiting, for use on all precision surfaces. Also des-

mbers of this family of "elec- lubricants." Protective Coating, 56-GL, Detroit 27, Mich.

M-32 **"The Burrell Technical An-** 16-page 7½" × 8¾" issue of se organ features an article on forms of sulphur in the indus- rket. Illustrated and described various Burrell technical prod- luding: "Glas-Col" electric heat- tles made of heat and corrosion glass cloth into which Nichrome elements are woven, used for ating; "Tru-Vac" vacuum gage, hot-wire principle; new devel- in gas analysis apparatus; the tic" reagent dispenser; a new timer adjustable for ¼ min. to ; Lindberg laboratory furnaces; ell wrist action shaker in three hold up to 16 flasks. Burrell Tech- pply Co., 1936-42 5th Ave., Pitts- 9, Pa.

M-327 **"Seedburo Equipment."** 112-page ″ × 11″ catalog pictures and describes plete line of Seedburo equipment. the many items listed are the electronic moisture tester for termining the moisture content of nd processed grains, dehydrated egetables, chemicals, nuts, plastic mold- compounds, resins, and other special oducts; official Brown-Duvel moisture sters and accessories; Tag-Heppenstall isture meter; Carter-Simon moisture ster for ground products; Brabender isture tester; forced draft ovens; elec- furnaces; grain thermometers; scales balances; and many other items of and industrial laboratory equipment. dburo Equipment Co., 223 W. Jackson d., Chicago 6, Ill.

M-328 **Folding Binocular Magnifier.** 6- 3½" × 6" folder pictures and de- bes the "Twin-Reader" compact fold- binocular magnifier. This instrument atures lenses of optical glass and is able for many kinds of close work. nses in power from 2 d. to 7 d. are ailable. N. L. Huebsch, 81 Yale St., East illiston, N. Y.

M-329 **Dimensional Quality Control mer.** 24-page 5½" × 8½" booklet de- ibes a simplified method for applying tistical quality control to dimensions, sed on the mathematical laws of proba- ity. Method warns when digressions reaching or have reached a danger- s percentage. Examples and suggested thods of filling out work sheets (avail- le from the manufacturer) are given. s plan is said to be adaptable as read- to the small plant as to the large. deral Products Corp., 1144 Eddy St., ovidence, R. I.

M-330 **Bore Inspection Telescopes.** 12- e 6" × 9" Bulletin No. 4400, pictures d describes the Gurley line of bore pection telescopes. The standard in- ument is suitable for bores of 37 mm. d larger in diameter. It is made in ts 6 ft. long, and may be provided th extensions, each 6 ft. long, up to a al length of 24 ft. Complete instruc- ns for use and care of the instrument included and a list of parts completes publication. W. & L. E. Gurley, Troy, Y.

M-331 **Two-meter Grating Spectro- ph.** 4-page 8½" ×11" catalog insert ures and describes the Dietert No. two-meter grating spectrograph. s new instrument can be supplied h 36,600 lines/in. or 91,500 total grat- lines, an unusually fine ruling. This it said, made possible the production of igh dispersion unit without resorting a bulky, long focal length. A 24" cam- provides a 20" spectrogram on 35-mm. ctrum film. Harry W. Dietert Co., 9330 elawn Ave., Detroit 4, Mich.

M-332 **"Engineering-design Develop- nt of X-ray Spectrometer."** 12-page ″ × 11″ reprint of an article by J. S. ler pictures and describes the Norelco ger Counter X-ray spectrometer for om tic recording and traces its de-

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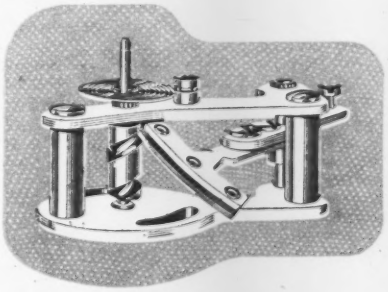

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velopment. The author discusses: x-ray diffraction principles, new instrument requirements, x-ray source, pulse conditioning, frequency meter circuit, counting meter circuit, indicators and controls, and applications. North American Philips Co., Inc., 100 E. 42nd St., New York, N. Y.

M-333 **Rotameter Insert for Measuring Large Flows.** Two 8½" × 11" catalog sheets, designated Bulletin Nos. 82-A and 83-A, picture and describe the new "Rotasleeve" insert for rotameter area type meters for measuring large flows. The "Rotasleeve" is a metal sleeve which fits into standard pipe tees from sizes 3" and upwards, is made for direct and remote reading in recording and recording-controlling types. Fischer & Porter Co., 93607P County Line Rd., Hatboro, Pa.

M-334 **"The General Radio Experimenter."** 12-page 6" × 9" July and August issue of this house organ features a heterodyne frequency meter for 10 to 3,000 megacycles. Part 1 of the article entitled, "How Humidity Affects Insulation," concerning d-c. phenomena, completes the issue. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

M-335 **Scales and Balances.** 36-page 8½" × 11" Catalog No. 643 pictures and describes an extensive line of scales. Designated a transition catalog, it lists standard scales and scales which were converted to meet wartime requirements. In addition to a complete scale for every commercial requirement, and computing scales, catalog shows pharmaceutical scales and portable balances. Detecto Scales, Inc., Division of the Jacobs Bros. Co., 1 Main St., Brooklyn, N. Y.

M-336 **"C-D Capacitor."** 16-page 5½" × 7¾" June 1945 issue of this house organ features an article describing a vacuum-tube a-c. voltmeter. Circuit diagrams of the voltmeter and its power supply are shown. "Tracing Radio Noise," a discussion of the location of internal receiver noises, is illustrated with diagrams and suggests remedies. Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

M-337 **Dial Light Sockets.** 16-page 8½" × 11" Catalog No. 101 pictures and describes dial light sockets for radio receivers and transmitters, test instruments and electrical equipment. More than 100 types with metal or plastic shells are shown, and dimensional drawings of various mounting bracket arrangements are shown. Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.

M-338 **Automatic Voltage Regulators.** 8-page 8½" × 11" Bulletin No. 164 pictures and describes the Seco line of automatic voltage regulators for line voltage control. Twenty-one types are available with input voltages ranging from 95-135 v. to 380-500 v. and regulated output voltages of 115 v. to 440 v. Refinements give a more compact and sensitive regulator. The speed of the thyratron tube control circuit has been increased to insure faster correction of line voltage fluctuations. Some models are now provided with a rapid-trip magnetic circuit breaker for overload protection and also as an on-off switch. Superior Electric Co., Bristol, Conn.

M-339 **"The Ohmite News."** 2-page 8½" × 11" August 1945 issue of this house organ features a biography of John Ambrose Fleming, who recently passed away at the age of 95. More than anyone else, Fleming was responsible for the marvels of the "electronic age," his name being associated with Maxwell, Marconi and Sir Oliver Lodge. To Fleming goes the distinction of recognizing the potentialities of the Edison Effect—the application of the two-element thermionic valve as a detector of wireless waves. Ohmite Mfg. Co., 4835-41 Flournoy St., Chicago 44, Ill.

M-340 **"DuMont Oscillographer."** 4-page 6" × 9" issue of this house organ, designated Vol. 7, No. 2, describes with diagrams and oscillograms the cathode-ray Q-meter, features the application of the cathode-ray oscillograph in measuring logarithmic decrement and Q. This method of plotting damped oscillations as fixed images on the cathode-ray tube has both electrical and mechanical significance. Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.

M-341 **Automatic Control Equipment.** 24-page 8½" × 11" Catalog V 1 pictures and describes with dimensional drawings a line of automatic control equipment for fluid systems. Listed are diaphragm control valves, pressure reducing and relief valves, and back pressure relief valves. Tables of working pressure data for valve bodies are given. Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.

M-342 **Marker Receiver for Aircraft.** 4-page 8½" × 11" bulletin pictures and describes the type MN-53-A and MN-55-A 75 megacycle marker receiver for aircraft. A new type of marker receiver, it is said to offer to the aviation industry more stable indicator lamp operation under varying conditions of supply voltage, temperature and humidity. Bendix Radio Division, Bendix Aviation Corp., Baltimore 4, Md.

M-343 **Running Time Recorders.** 6-page 8½" × 11" Bulletin OP1502 pictures and describes the Bristol running time recorders for machines, pumps, presses and similar equipment. These instruments record on a chart the "on" and "off" times of production machinery and other similar equipment, as well as the time at which they occurred. They are available with 8" or 12" charts in models for 24, 115 or 230 v., 60-cycle current. The Bristol Co., Waterbury 91, Conn

M-344 **Timing Instruments.** 8½" × 11" bulletin pictures and describes a line of timing instruments for various purposes. Listed are several timers of the stop-watch type, some with time-out feature, and two-hand tachometers of the continuous-indicating type. A. R. & J. B. Meylan, 264 W. 40th St., New York 18, N. Y.

M-345 **"Aminco Laboratory News."** 8-page 8½" × 11" July 1945 issue of this house organ contains a number of articles, among them: "New Standard Samples of Hydrocarbons Now Available," "Smoothness of Metallic Surfaces Determined by Plastic Replicas," "New Cameras Take 8000 Pictures per Second." An article entitled "New Use Discovered for X-rays," discusses a new discovery whereby x-rays and other radiations are used to alter the elastic constants and chemical properties of quartz and other crystalline substances employed in radio and radar, so that oscillator plates can be adjusted rapidly and easily to a desired frequency with a precision hitherto impossible. American Instrument Co., 8030-8050 Georgia Ave., Silver Spring, Md.

M-346 **Circular Levels.** 4-page 3½" × 6¼" folder pictures and describes a line of circular levels for industrial and laboratory applications. Mounted and unmounted models are shown, and mountings may be designed to the buyer's specifications. Ground or plain tubular spirit level vials are also available from the manufacturer. Geier & Bluhm, Inc., Troy, N. Y.

M-347 **Dynamotors, Converters, etc.** 4-page 8½" × 11" Bulletin No. 445 pictures and describes a line of rotary electric power supplies including dynamotors for all mobile radio equipment; genemotors for 2-way police radio-amplifiers, FM and small aircraft communications; Magnemotors, permanent magnet field motors; generators for amplifiers, police radio receivers, small aircraft transmitters, portable life saving devices; d-c. to a-c. converters for amplifiers, radio, public address and other uses; hand generators for portable communications power supplies at sea, in the field, etc. Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

M-348 **Hermetically Sealed Electrical Indicating Instruments.** 12-page 5" × 7" catalog presents a line of glass-to-metal hermetically-sealed electrical indicating instruments in 2½" and 3½" sizes. Complete details of the method of sealing are given, tests to which the instruments were subjected are reported, and the instruments available are listed. Marion Electrical Instrument Co., Manchester, N. H.

M-349 **Electrical Power Analyzer.** 2-page 8½" × 11" catalog sheet pictures and describes the Niagara dual-purpose electric power analyzer for a-c. power measurement. The instrument, housed in a carrying case, has facilities for making the following measurements in single-phase, 2-phase or 3-phase current: amperes 0-300, volts 0-600, watts 0-300 million to 240,000. Niagara Electrical Instrument Co., 204-210 Franklin St., Buffalo 2, N. Y.

M-350 **Anti-capacity Switches.** 8½" × 11" catalog sheet pictures and describes anti-capacity switches for various uses. Available in 4 spring d-p. s-t., 6 spring d-p. d-t., and 12 spring 4-p. d-t. models they are supplied with a highly polished nickel-plated bronze face. Springs are of phosphor bronze, silver-plated. Cam arrangement is of the roller type. Federal Anti-Capacity Switch Corp., 1200 Niagara St., Buffalo, N. Y.

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M-351 **Hydraulic Pressure Controls.** 8-page 3¼" × 6¼" folder pictures and describes a line of hydraulic pressure controls, regulators and valves. Included are pressure regulators in 6 standard ranges from 0 to 2000 lbs. for pipe sizes from ¼" to 2"; pressure reducing valves from 0 to 3000 lbs.; a feed control and deceleration valve with graduated setting dial; solenoid-pilot-operated 2-, 3- and 4-way valves; sequence valves which provide successive control of several machine functions. Vinco Corp., 8855 Schaefer Highway, Detroit 27, Mich.

M-352 **"The Visco Meter."** 12-page 6½" × 9" booklet pictures and describes an instrument for indicating viscosity of lubricating oil in engine crankcases. It is made in a number of models for different types of applications, and each is pre-set at the factory for its specific application. The reading is continuous, changing instantly as the viscosity of the oil changes with engine temperature. Visco-Meter Corp., 315 Grote St., Buffalo, N. Y.

M-353 **"Micro Topics."** 8-page 8½" × 11" August-September issue of this house organ contains a number of items of interest to the radio and sound fields. Universal Microphone Co., Inglewood, Calif.

M-354 **Beat Frequency Generator.** 20-page 8½" × 11" booklet gives instructions for the manufacturer's "Type 140-A" beat frequency generator. Specifications, installation, operation and maintenance are all covered. Circuit diagrams and a description of the "Type 144-B" output unit, designed to match the output of the "140-A" to a 72-ohm external resistance, are also included. Boonton Radio Corp., Boonton, N. J.

M-355 **Abraser Test for Potential Wear.** 4-page 8½" × 11" booklet describes the abraser test as revealing exactly the information wanted about surface wear due to rubbing abrasion. Shown also are a few typical examples of material—paints, lacquers, plastics, rubber and synthetic materials, leather, linoleum, and textiles—whose wear factor can be readily determined. Taber Instrument Corp., North Tonawanda, N. Y.

M-356 **Temperature Compensation Units.** Single-page 8½" × 11" bulletin pictures and describes maker's line of thermal resistors and their advantages, behavior and efficiency. These resistors are said to be extensively used for temperature compensation, temperature measurement and control, time delay and other applications. Keystone Carbon Co. Inc., St. Marys, Pa.

M-357 **Oil Viscosity Indicator.** 4-page 8½" × 11" folder describes the operation and purpose of the "Viscometer," a continuous oil viscosity indicator, together with instructions for maintenance. Visco-Meter Corp., 315 Grote St., Buffalo, N. Y.

M-358 **"CD Capacitor."** 16-page 5" × 8" July 1945 issue (designated Vol. 10, No. 5) of this house organ features article describing the construction of simple signal tracer, incorporating an electronic voltmeter, for those who were not fortunate enough to obtain elaborate signal tracers. Article points out that those who do own other types of tracers will find this simple signal tracer advantageous and interesting. Cornell-Dubilier Electric Corp., Hamilton Blvd., So. Plainfield, N. J.

M-359 **"The Invisible World and Other Stories."** 20-page 6" × 9" Pamphlet No. GES-2962 tells of General Electric Company's history, research activities, and contributions to American progress. This illustrated pamphlet is one of a series published by this manufacturer. Others in the series are: "The Story of Steinmetz," "Story of G-E Research" and "Story of Lightning." General Electric Co., Dept. 6-318, Schenectady 5, N. Y.

M-360 **Electrical Indicators.** 4-page 7½" × 10½" folder pictures and describes maker's 1.5" "Type OD" commercial d-c. milliammeter, 2.5" "Type DA"

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commercial a-c. voltmeter, 2.5" "Type G-1" aircraft d-c. ammeter; and reproduces a letter, pertaining to these instruments, from the Army Air Forces Air Technical Service Command. Roller-Smith Co., Bethlehem, Pa.

M-361 **Rotary Solenoid.** 8-page 6" × 9" booklet, designated as Form No. 101-9-45, pictures and describes the "Ledex" rotary solenoid powered by d.c. and applicable to numerous remote controls and special power units on airplane, automobile, water craft, diesel drive, power stations, or where d.c. is available. The solenoid can be used to operate from a.c. by using a provided rectifier. It is frictionless, powerful, adaptable and slightly larger than a pocket watch in diameter. Included also is an exploded view, an illustration conveying the torque characteristics. George H. Leland, Development Engineering, 123 Webster St., Dayton 2, Ohio.

M-362 **Variable Voltage Transformer.** 12-page 8½" × 11" Bulletin No. 149A describes and illustrates the Powerstat which regulates power input (and hence temperature) of many types of electric furnaces and ovens. Features such as rating, efficiency, applications and control possibilities are given consideration in this bulletin. Superior Electric Co., Bristol, Conn.

M-363 **Plugs for Aircraft Electrical Circuits.** 68-page 8½" × 11" book designated as Type K Bulletin describes and illustrates "Type K" and "RK" plugs, receptacles, dust caps, junction shells, stowage receptacles for aircraft, instruments, radio, motors, geophysical equipment and general electrical applications. Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.

M-364 **Portable A-c. Test Sets.** 24-page Bulletin GEA4477 describes and pictures a complete line of portable a-c. test-sets which range from 2000 to 150,000 volts. This illustrated bulletin enables the user of high-voltage testing equipment to compare the features and ratings of various available standard sets. Covered in this bulletin are small insulation testers, oil testers, and larger general-purpose test sets. Listings and descriptions of sphere gaps and current-limiting resistance assemblies for use with a-c. testing sets are also included. General Electric Co., Schenectady 5, N. Y.

M-365 **"The Capacitor."** 16-page 5½" × 7½" September issue of this house organ designated as Vol. 10 No. 9 features an article on Tone Control Circuits with instructive diagrams; and another article (continued from previous issue) on Power Transformer Servicing. Latter includes a data chart that should prove useful when rewinding primaries for transformers. Five pages of "The Radio Trading Post" for those who have a legitimate wanted, sell or swap proposition to offer. Cornell-Dubilier Electric Corp., Hamilton Blvd., S. Plainfield, N. J.

M-366 **Hermetically Sealed Instruments.** 4-page folder designated as Form 4545-T pictures and describes instruments hermetically sealed and various tests to which they were exposed in order to study the behavior and the resultant effects. Several models are covered in this folder and disassembled and cross-sectional views convey the completeness of the sealing. Triplett Electrical Instrument Co., Bluffton, Ohio.

M-367 **"Solving Industrial Crimes."** 16-page 4¼" × 5¼" booklet (designated as "Case No. 31") describes and pictures graphic instruments used by various industries to recognize and remedy unexpected waste; high-speed recorders and indicators provided with external motors to speed chart up to 3600 times normal rate; recording ohmmeters; time recorders; relays; long-distance transmitters; pressure recorders and portable current transformers. Esterline-Angus Co., Inc., Indianapolis, Ind.

M-368 **Radio and Electronic Equipment.** 36-page 8½" × 11" catalog illustrates such items as: electronic receiving tubes, test equipment, panel meters, timers, soldering irons, electric drills, photoelectric controls, floatless level controls, furnace reversing drum controllers, switches, fluorescent lighting testers, oscillographs, etc. Walker-Jimieson, Inc., 311 S. Western Ave., Chicago 12, Ill.

M-369 **Combustible Gas Indicator.** 4-page 8½" × 11" Bulletin No. 11 describes and pictures continuous combustible gas indicator which analyzes continuously and handles any combustible gas or vapor. The operation principles and a cutaway view are also included. Johnson-Williams, Ltd., 847 Emerson St., Palo Alto, Calif.

M-370 **Automatic Radio Compass.** 8-page 8½" × 11" folder designated as Series MN-31 describes and pictures a continuous-indicating automatic radio compass and gives the performance specifications and salient features. Bendix Radio Div. of Bendix Aviation Corp., Baltimore 4, Md.

M-371 **Safety Control System for Shutdown of Diesel Engines.** 4-page 8½" × 11" bulletin describes "Type R-18" safety control system for shut-down on diesel engines when temperature of circulating water system becomes too high, or when lubricating oil pressure is low. Also summarized are the operating procedures, which are accompanied by drawings. Viking Instruments, Inc., Stamford, Conn.

M-372 **"C-D Capacitor."** 16-page 5" × 8" August issue (Vol. 10 No. 8) of this house organ features two articles: one on Push-pull amplifiers and Phase Inverters; and the other on Power Transformer Servicing. The "Radio Trading Post" occupies 5 pages of items listed to sell, swap or buy. Cornell-Dubilier Electric Corp., Hamilton Boulevard, S. Plainfield, N. J.

M-373 **"The General Radio Experimenter."** 8-page 6" × 9¼" September 1945 issue (Vol. XX No. 4) features a precision tuning fork with vacuum tube drive, and gives information on the operating characteristics, constructional features and general specifications. Issue includes an article on Production Testing With Impedance Bridges, and another on Balancing to 70 Millionths of An Inch With Aid of Strobotac. General Radio Co., 275 Mass. Ave., Cambridge 39, Mass.

M-374 **Automatic Control for Glass Industry.** 12-page 8½" × 11" Bulletin No. 127 describes the role automatic control has played in the glass industry and gives diagrams of a modern glass tank that uses various controls such as furnace pressure regulator, combustion regulator, heat input regulator etc. Bulletin includes brief discussions of the controls as well as features of the company's jet regulator. Askania Regulator Co., 1603 S. Michigan Ave., Chicago, Ill.

M-375 **Vibrating Reed Frequency Meters.** 16-page 7¾" × 10½" Bulletin No. 1770 illustrates and describes the various types of this company's vibrating reed frequency meters. Explanations of the resonant-reed principle and vibrating-reed characteristics are included, as well as a cutaway view of the switchboard type showing construction and adjustment features. James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa.

M-376 **Counting, Timing and Recording Devices.** 8-page 8½" × 11" catalog describes and illustrates stroke and revolution counters, electric counters, coil winding and predetermined electric counters; also includes application information which brings out the sizes, features, advantages and specifications of these devices. Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.

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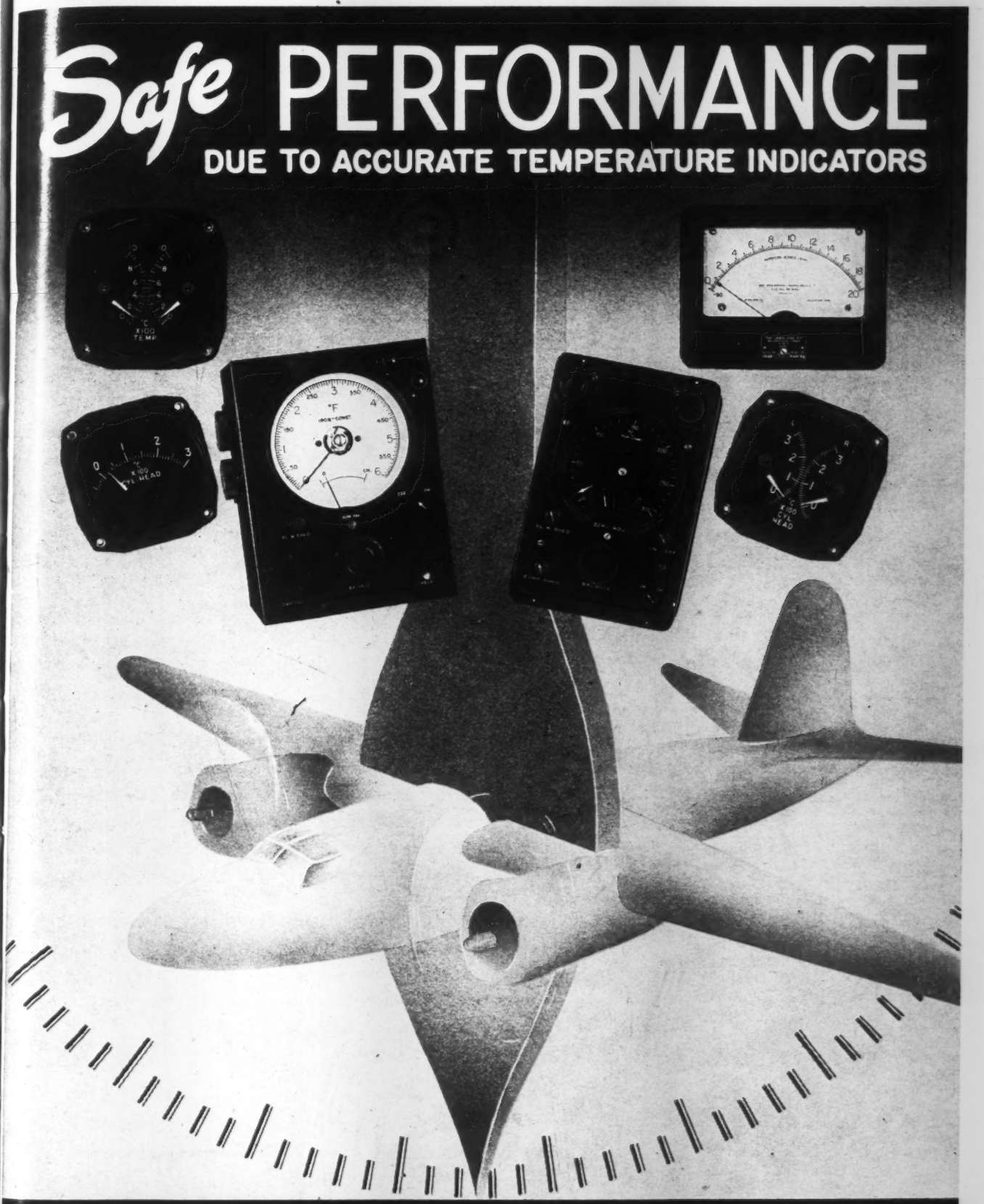

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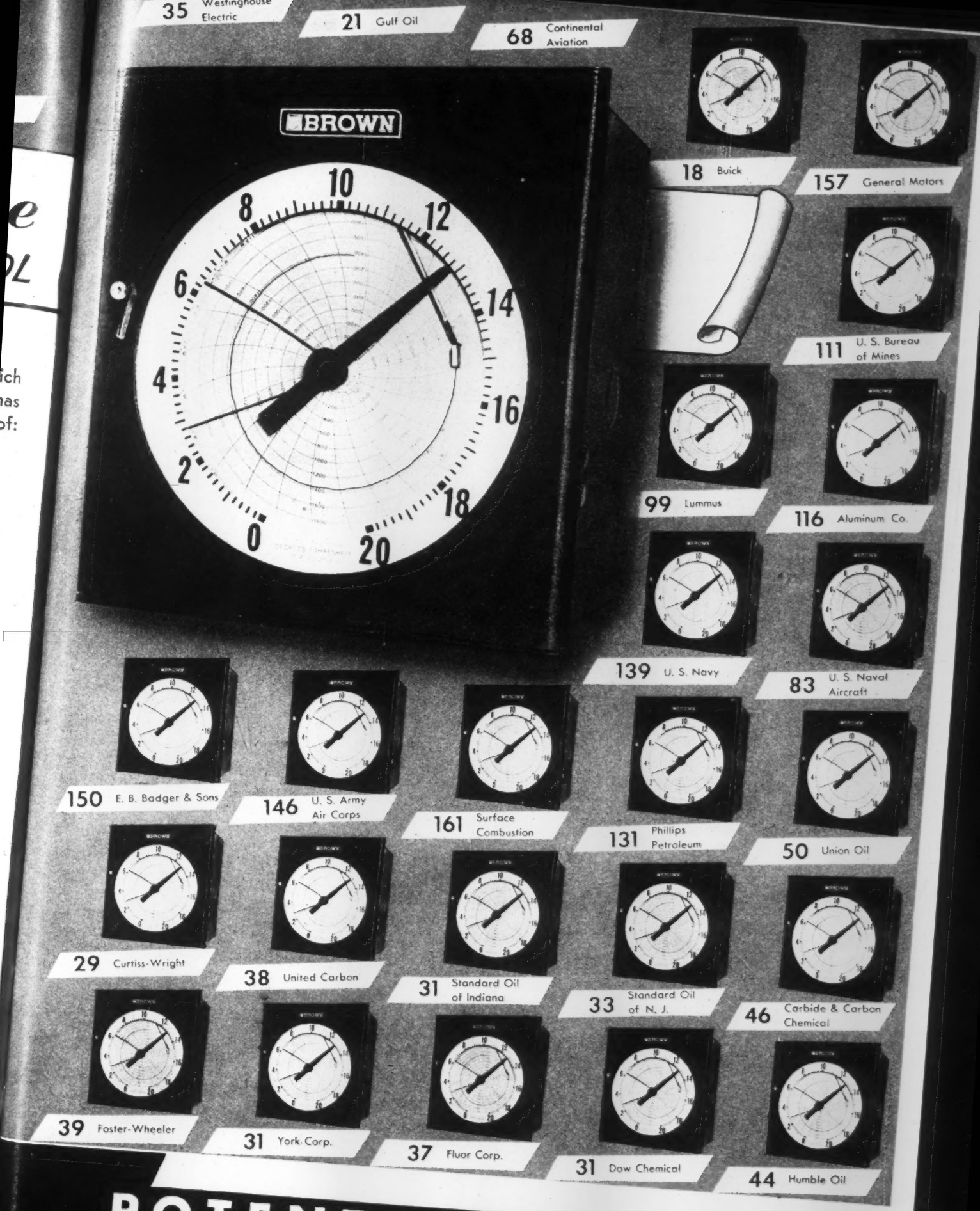

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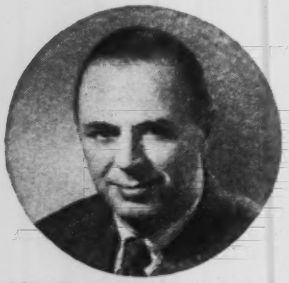

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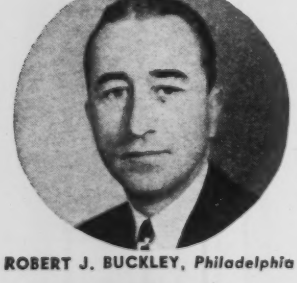

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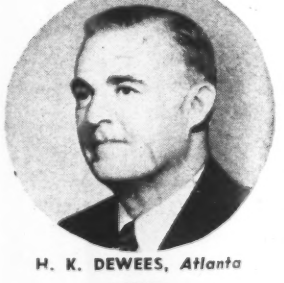

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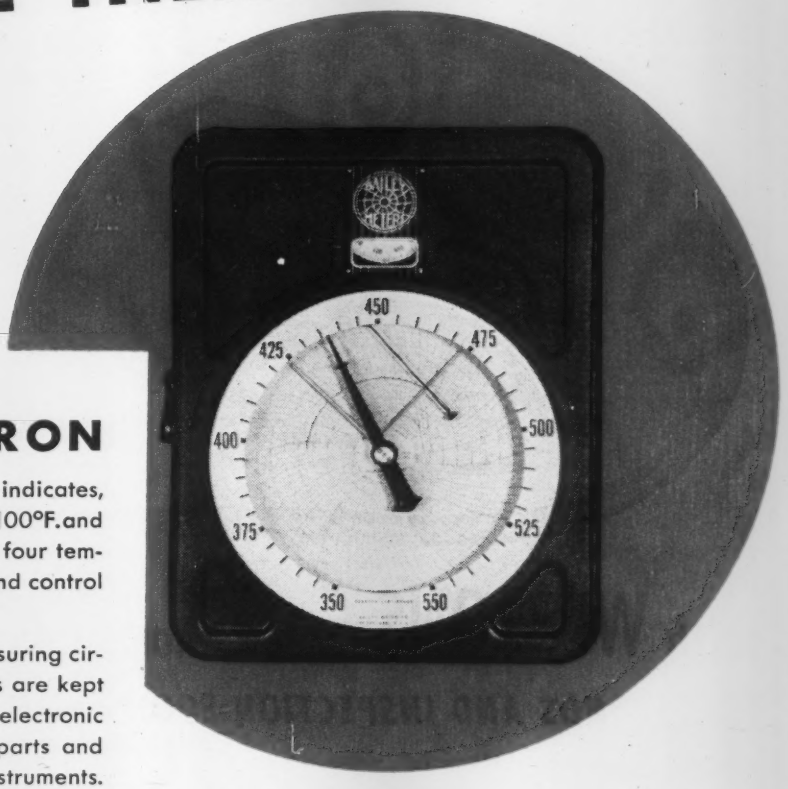

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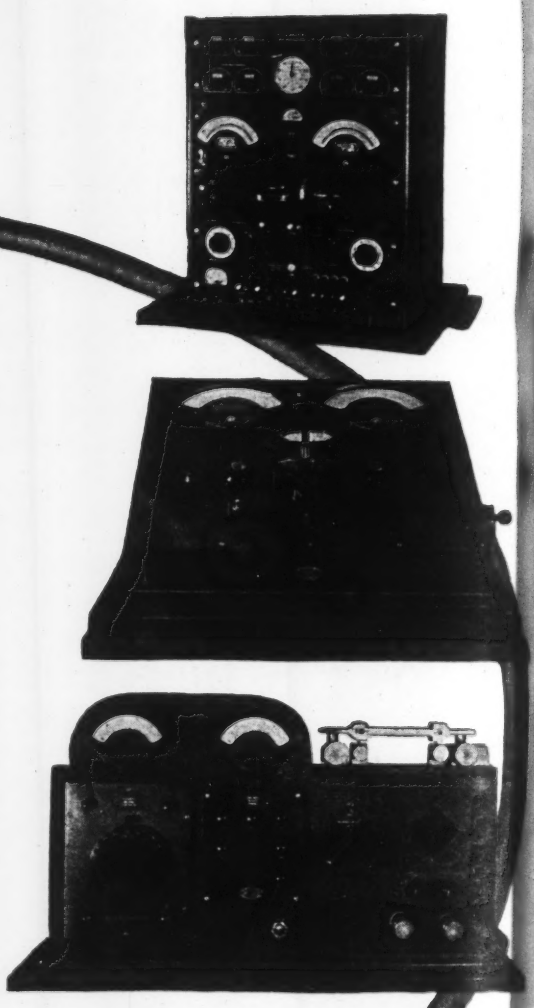

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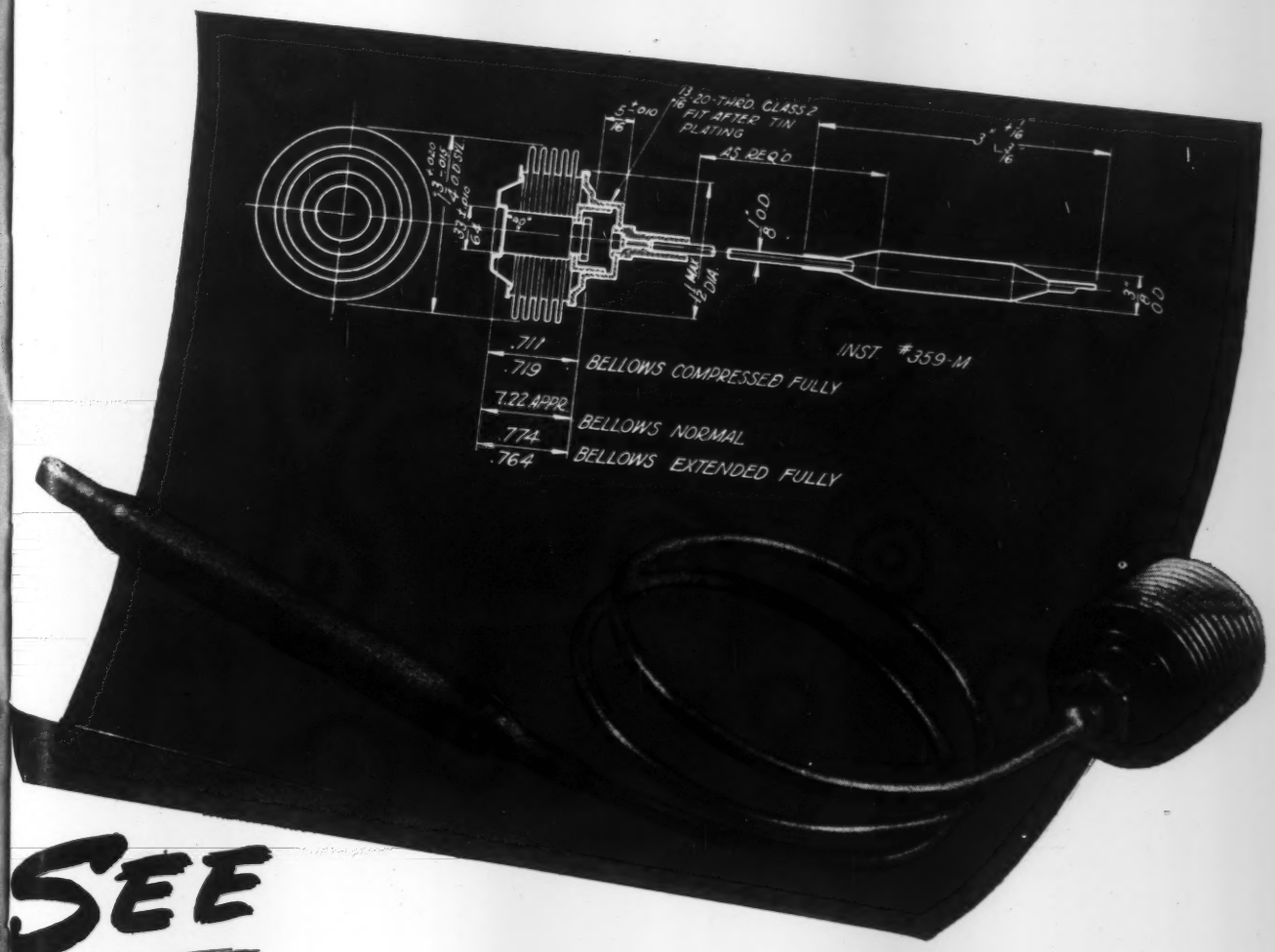

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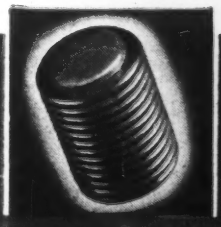

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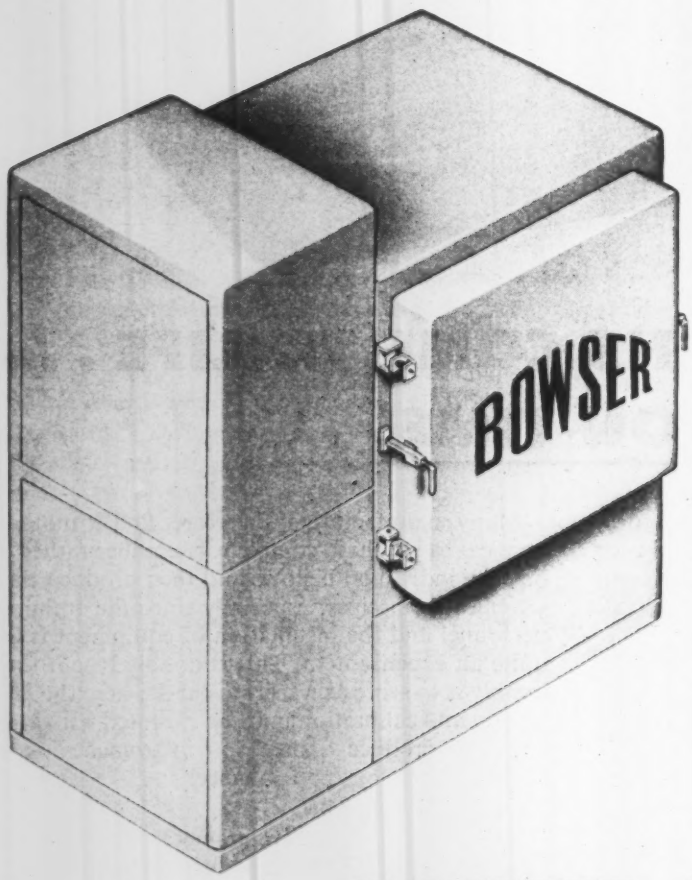

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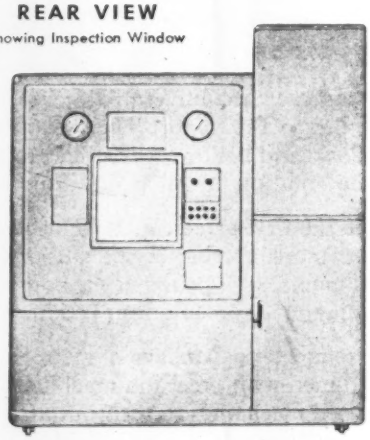

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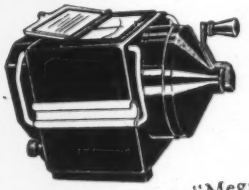

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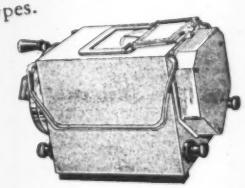

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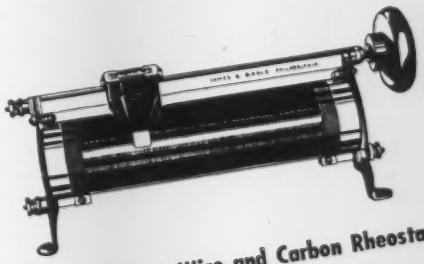

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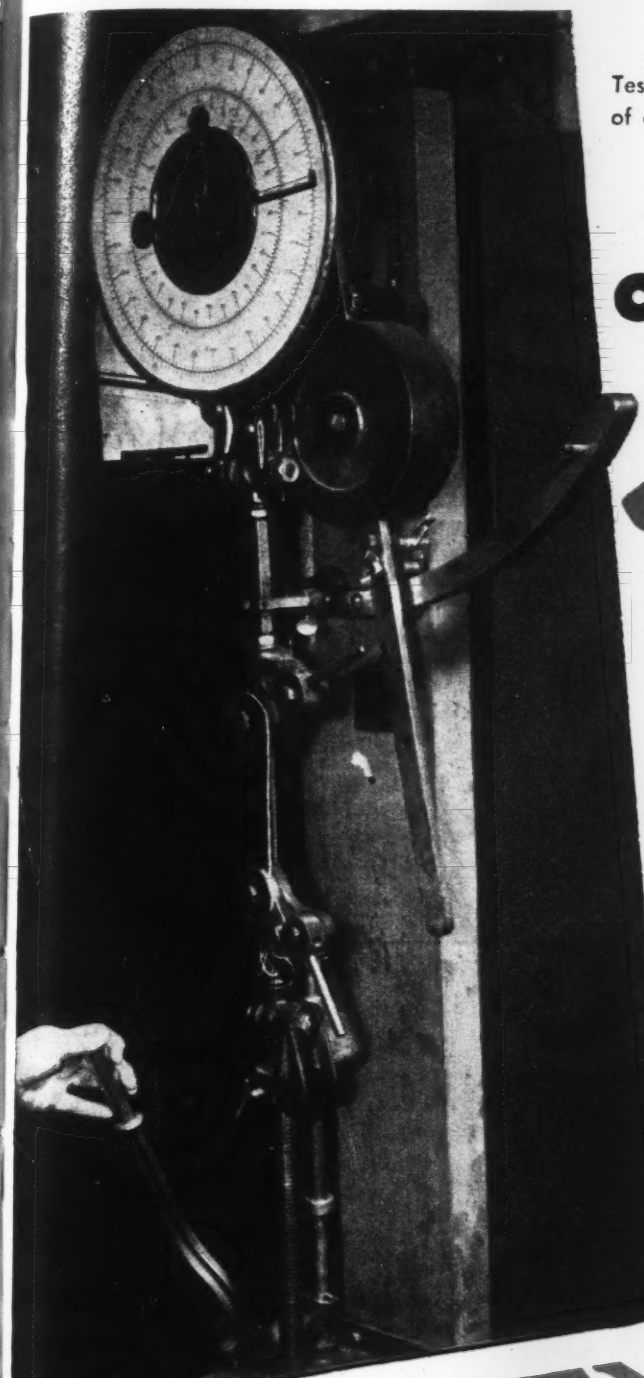

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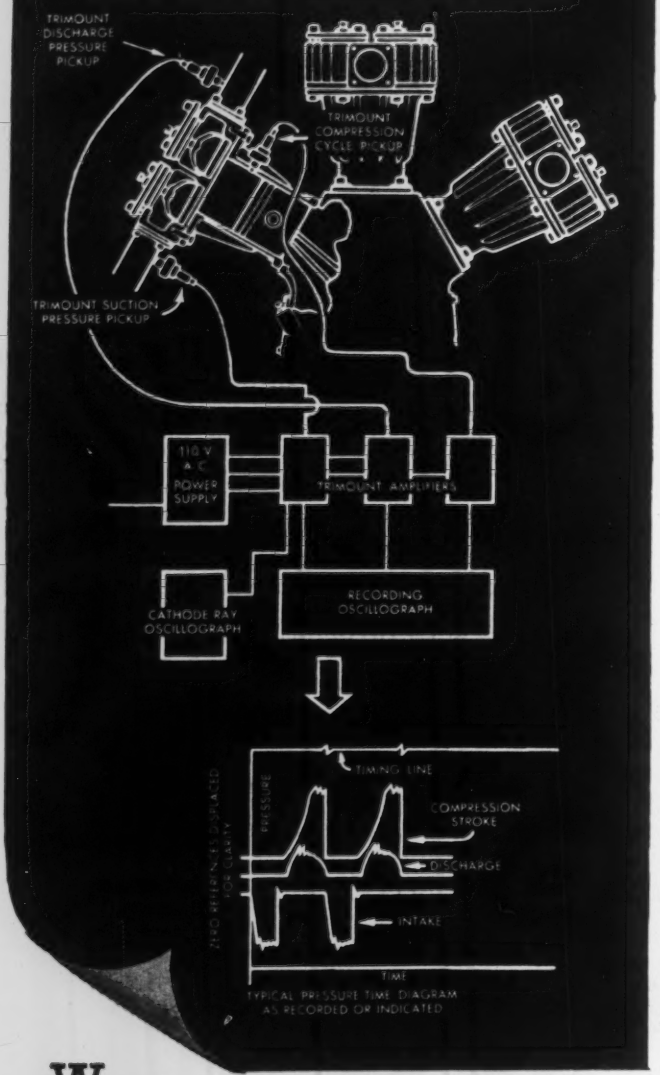

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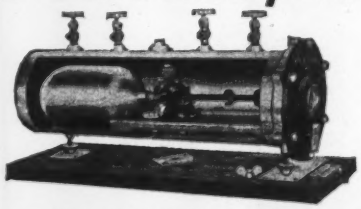

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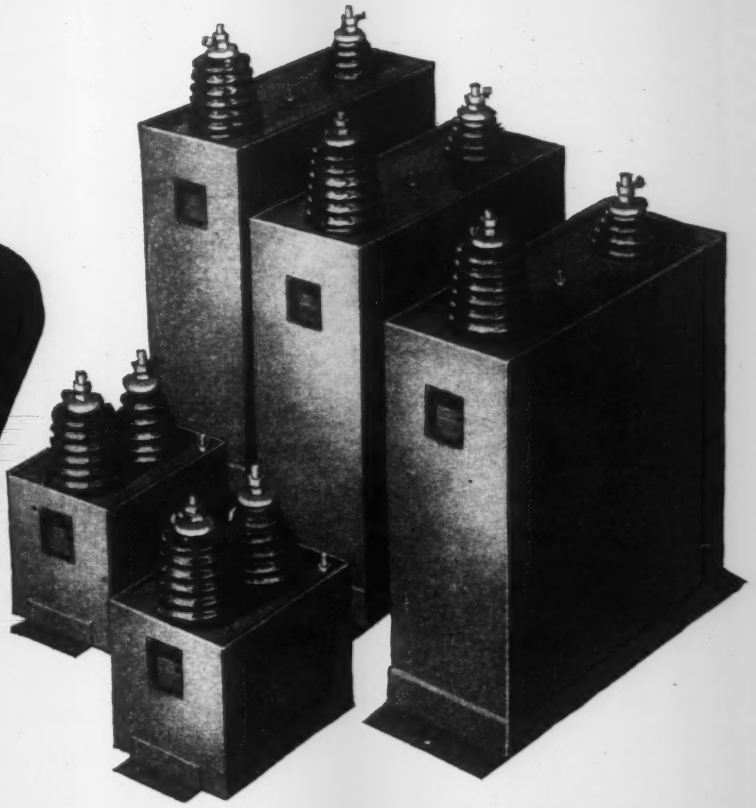

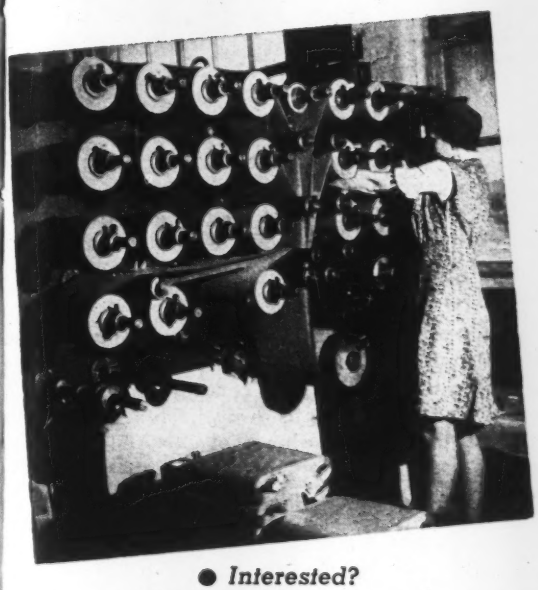

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Write for detailed literature.

● Outstanding production equipment in the hands of Aerovox craftsmen, accounts for these veritable capacitor dreadnaughts. In exacting services such as radio transmitters, heavy-duty electronic equipment, and in the electric power field, these units have won citation after citation for exceptional ruggedness.

Such ruggedness stems from the Aerovox winding facilities second to none. Special winding machines insure that the multi-layered sections are uniformly and accurately wound under critically-controlled tension. Also, a system of impregnation tanks, pumps and control equipment guarantees the necessary drying after vacuum impregnation that is positively unexcelled by any impregnation process anywhere.

Hermetically-sealed welded steel containers; heavy-duty porcelain insulators; cork gaskets and pressure sealing; nonferrous metal hardware; silver-soldered joints; sturdy mounting means—these are the externals of these capacitor dreadnaughts. Standard listings of Type 20 up to 50,000 v. D.C.W. Capacitances from 0.1 to 10 mfd.

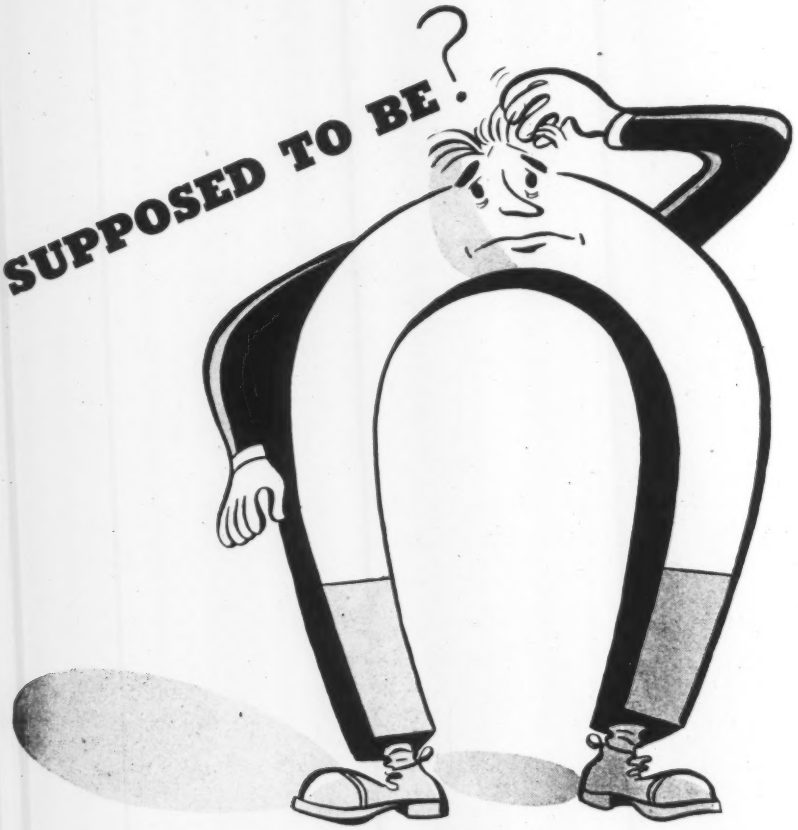
AEROVOX *Capacitors*

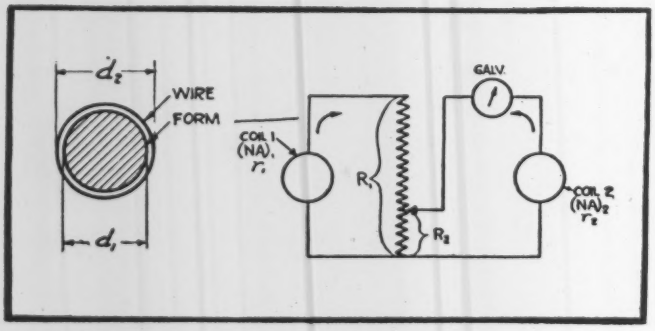
INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. · SALES OFFICES IN ALL PRINCIPAL CITIES

Export: 13 E. 40 ST., NEW YORK 16, N. Y. · Cable: 'ARLAB' · In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

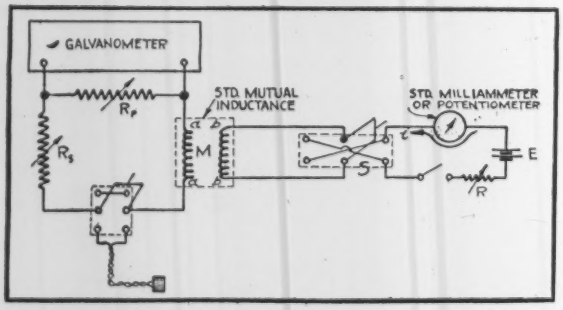
AM I WHAT I'M SUPPOSED TO BE?





(left)—Cross-section of single-layer search coil

(right)—Circuit for measuring the NA product of a multi-layer search coil



Standard ballistic galvanometer circuit

I'm supposed to do a certain job. The manufactur made me according to the blue prints you sent hi and he tested me thoroughly but how are you goin to find out if I'm really what you want for the jo that has to be done?

It's simple. Just rig up a search coil of the proper siz and a ballistic galvanometer (two bits for that on and you can put me through a pretty good third d gree of your own. There also are other ways of tes ing me and the people who made me—CINAUDA GRAPH—will be glad to send you instructions how t make simple test units. Write for their booklet PER MANENT MAGNET DESIGN.

This booklet contains more than a dozen pages of rea meaty information about permanent magnets. It dis cusses mounting, testing and casting and heat-trea ing insofar as they apply to design. This booklet wa prepared by the chief engineer of CINAUDAGRAPH He and his associates have helped many a manufac turer of electrical instruments or apparatus to get o the right track insofar as permanent magnets are con cerned.

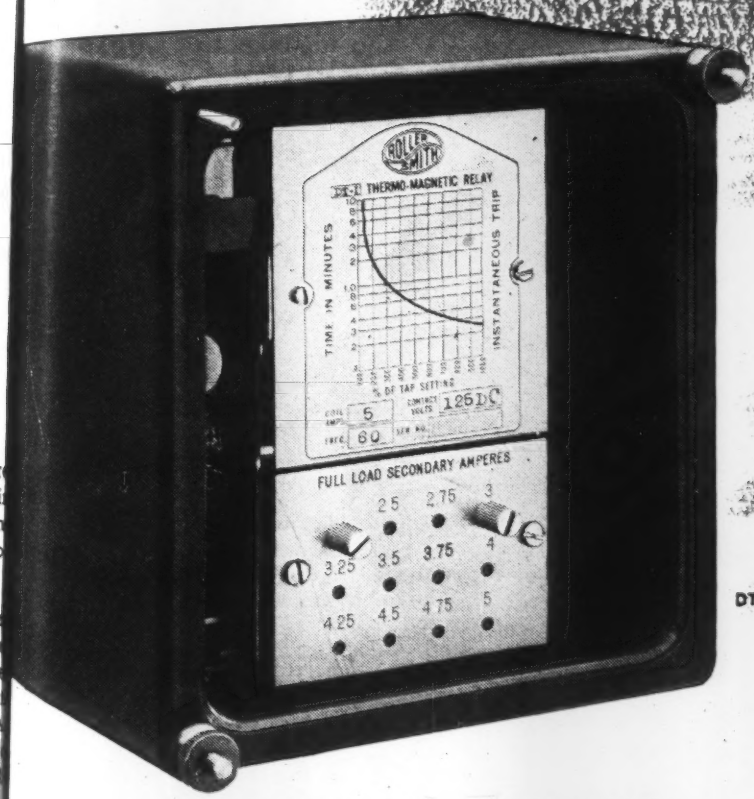
CINAUDAGRAPH CORPORATION
4 Selleck Street Stamford, Connecticut

12-CC-2

CINAUDAGRAPH CORPORATION

GET THIS 2 WAY PROTECTION

FOR MOTORS · GENERATORS · TRANSFORMERS



Time Delay
Thermal Overload Protection

Instantaneous Trip
Overcurrent Protection

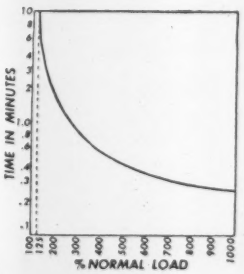
DT-1—THERMO-MAGNETIC RELAY

HERE IS HOW IT WORKS—

ove 10 times normal current the magnetic trip oper-s. From 10 times down to 1.25 the circuit opens after indicated time delay. ➡

If you want to avoid expensive breakdowns of uipment due to unsafe overloads, you need the al protection of the Roller-Smith type DT-1 ermo-Magnetic Relay.

u get protection from dangerous overloads by ans of a bimetal relay that opens the circuit



before the winding temperature of the protected equipment becomes dangerous. There is a time delay before the relay opens which runs around 10 minutes at 125% rated load and 15 seconds at 1000% rated load. The magnetic trip operates instantly for currents in excess of 10 times rated load, the control circuit opens and the equipment comes off the line. For detailed information on the application and operation of the DT-1 overload relay, write for Catalog 6240 to Department IN-6.

ROLLER SMITH

Switchboard Instruments

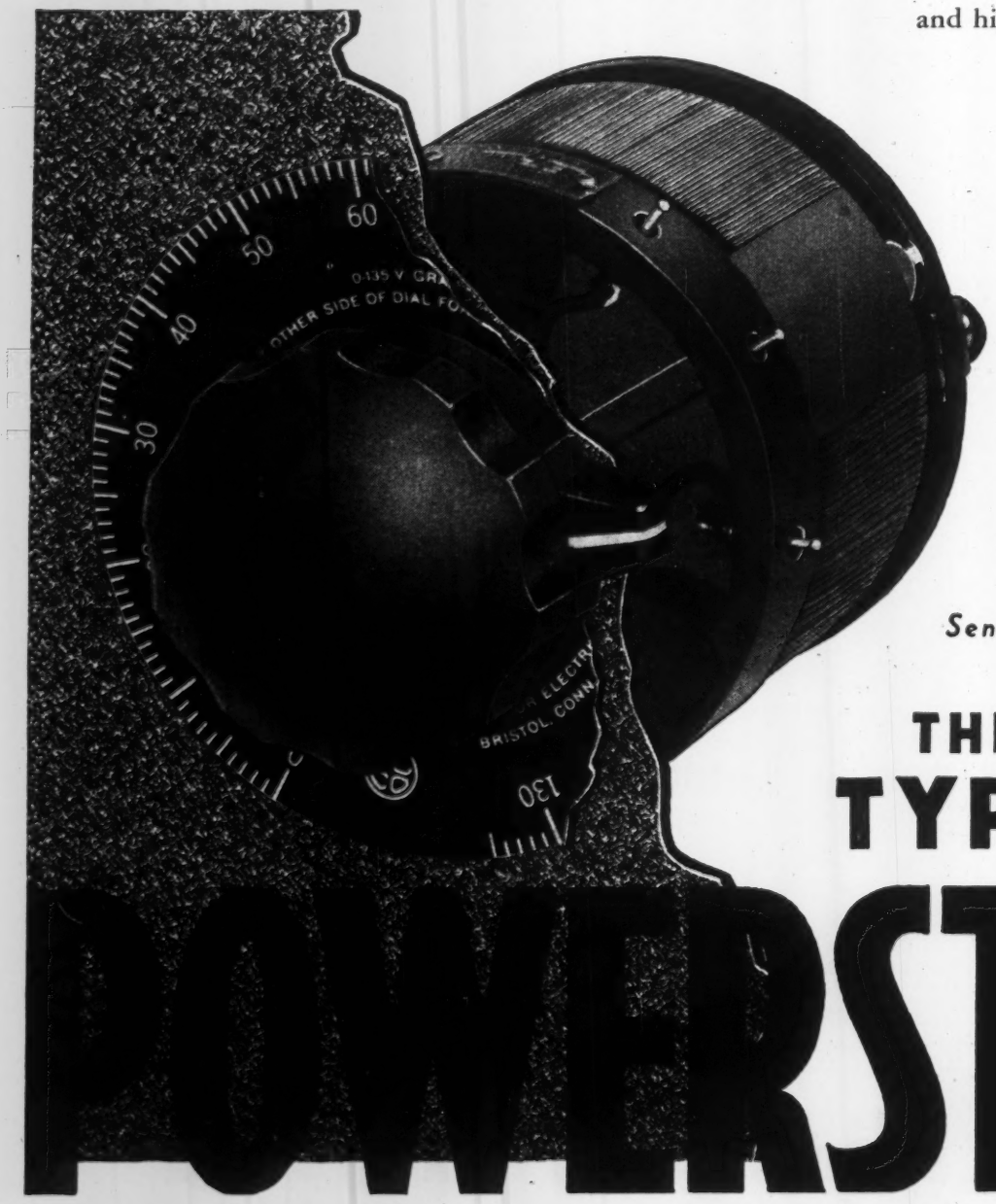
BETHLEHEM·PENNSYLVANIA

In Canada: Roller-Smith Marsland, Ltd., Kitchener, Ontario

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR
AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES

Here's the ACTUAL SIZE

In announcing another new and smaller POWERSTAT variable transfo me SUPERIOR ELECTRIC COMPANY offers in the Type 20 all the desirable characteristics of larg POWERSTATS together with design features only applicable to a unit of this size. Use of speci core materials and an unusual mechanical arrangement permits mounting on 1¼ inch radiu The space required behind the panel is only 3 9/16 inches. Although small in physical dimension the rating of type 20 illustrates the advanced desig and high quality workmanship



Input: 115 volt, 50/6 cycles, 1 phase.

Output: 0 to 135 volt 3 amperes, 405 va.

Weight: 3.9 lbs.

Questions regarding technical data, delivery or price will be gladly answered by any SECO engineer.

Send for Bulletin S1

THE NEW TYPE 20 POWERSTAT

SUPERIOR ELECTRIC COMPANY

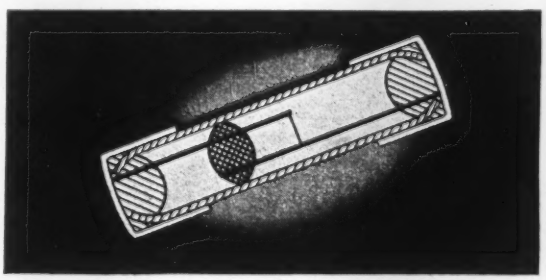
431 LAUREL STREET, • • • BRISTOL, CONNECTICUT

First in Circuit Protection

Quicker than a Lightning Flash!

High-speed 8 AG Instrument Fuses are another Littelfuse first—the first to protect under ¼ amp. and, for over 18 years, a reliable protective fuse for safeguarding delicate instruments — galvanometers, microammeters, thermocouples, milliammeters, radio tubes, testers, rectifier tubes, etc.

The Littelfuse patented construction insures consistent high-speed action, opening circuit long before overload reaches dangerous magnitude.



These "quicker than a short circuit" Littelfuses are available in current ratings from 1/200 amp. to 2 amps. at 250 volts or less (1″ x ¼″ dia.)

Also available—wide selection of instrument fuse mountings and fuse extractor posts.

LITTELFUSE INCORPORATED
4757 N. Ravenswood Ave., Chicago 40, Illinois

Plants in Chicago and El Monte, California.

QUALITY IS BASIC

Today, our business continues to expand as satisfied customers voluntarily recommend our fuses to the manufacturers of airplanes, automobiles, radios and electronics equipment . . . and to the utilities and building industries, as well. The reputation which we won prior to the war, gave us the opportunity to design circuit protection devices for the Army, Navy and Air Forces. Early in the war, we were awarded the Army and Navy "E".

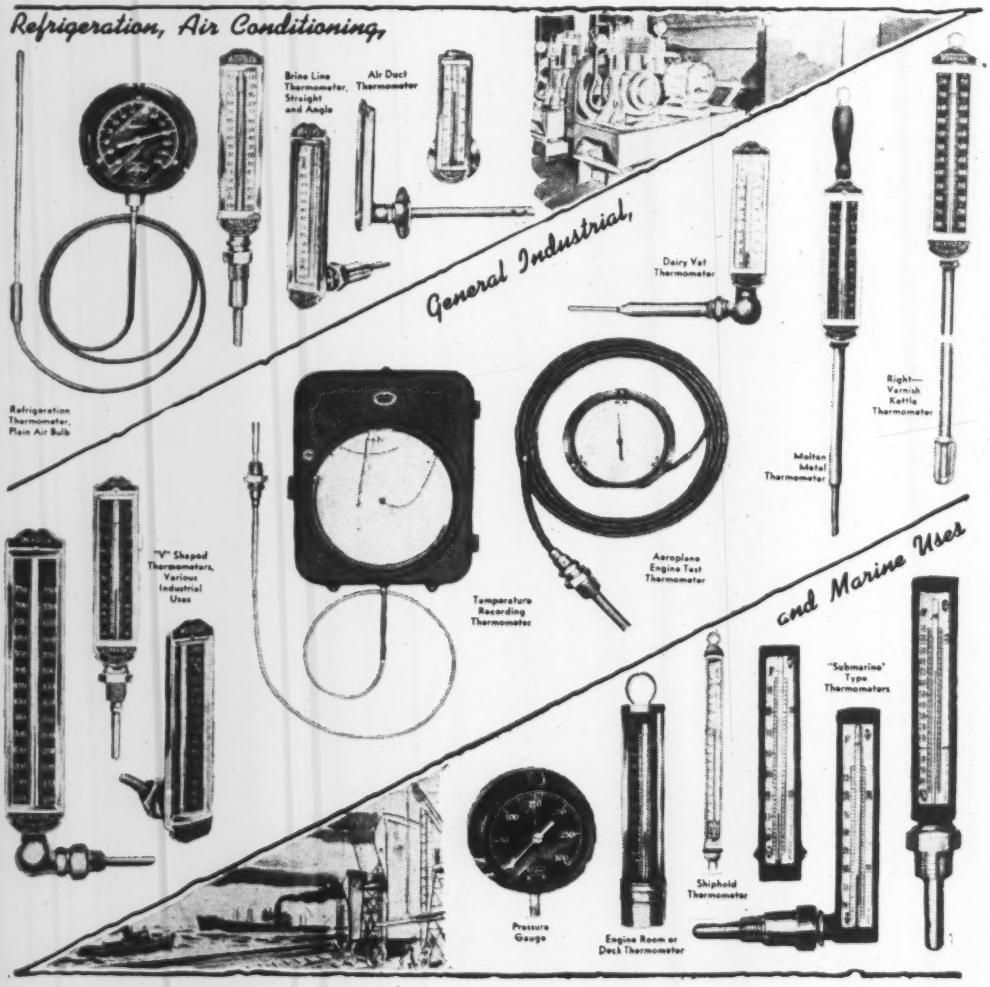
Throughout the years of progress, never have we lost sight of the basic fundamental on which our business was founded, namely: a quality of workmanship and materials which makes for precision in circuit protection and safety.

President

LITTELFUSE *Incorporated*

WEKSLER
N.Y.C.

Instruments to Indicate and Record Temperature, Pressure and Humidity were nearly 100% drafted for war jobs all over the globe. We are proud that instruments bearing the name of WEKSLER made good—EVERYWHERE—in the sky, over and under the sea, in research and in production.



Now that victory is finally ours, WEKSLER again can promptly supply Industry with all types of ruggedly built, lastingly accurate Thermometers, Hydrometers, Hygrometers, Psychrometers and Gauges—for use wherever Temperature, Pressure or Humidity is a factor in research or manufacture.

YOUR INQUIRIES ARE EARNESTLY SOLICITED!

WEKSLER THERMOMETER CORPORATION
52-56 West Houston St., New York 12, N. Y.

HERE ARE ALL THE FACTS ABOUT THE

SIMPLEX TYPE MO METER

The High-Accuracy Flow Rate Meter

Write today for your copy of Bulletin 300 which details the operation, use, specifications, and accuracy of the Simplex MO flow rate meter. Specified by operating men and management from coast to coast.

SIMPLEX VALVE & METER COMPANY

6786 UPLAND STREET, PHILADELPHIA 42, PA.

INTRODUCING!

. . . MARK-TIME'S LATEST CONTRIBUTION TO A FAMOUS LINE OF TIME SWITCHES

1. **Automatically switches electric current ON or OFF at completion of a pre-selected time period.**

2. **At the end of this time cycle, the New Mark-Time Double Purpose Timer sounds a clear ringing signal.**

3. **Underwriters approved switch mechanism.**

Here is an opportunity to add new features to your product. Our Engineering Department will be pleased to consult with you.

Our latest device combines all the advantages of a time switch with those of an interval timer.

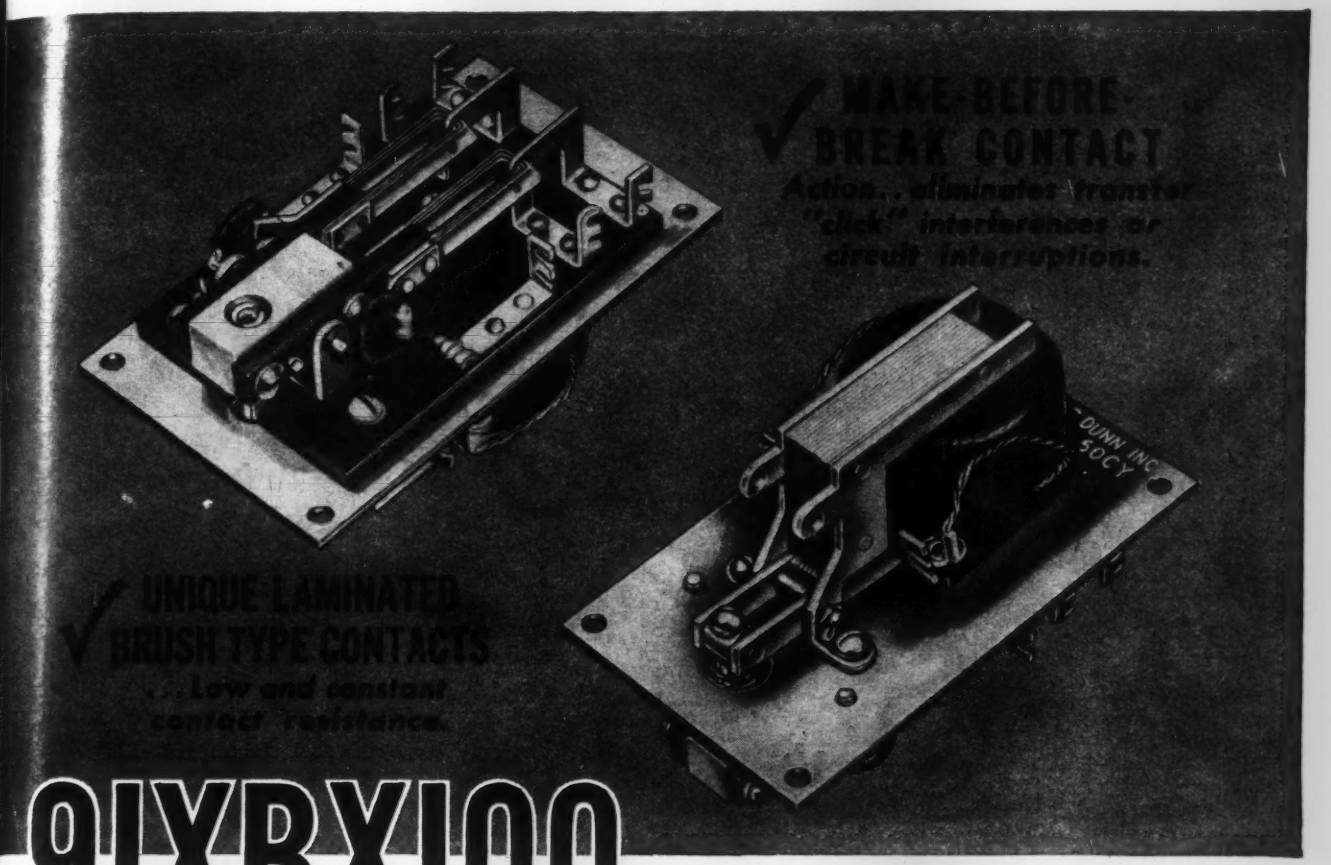
For instance, the housewife who loads her washing machine and proceeds with other household chores will be reminded with a mellow note from the New Mark-Time Double - Purpose Timer that the device has switched off the machine.

Similarly, many industrial operations may be controlled with this versatile time switch —the latest addition to the Mark-Time family.

MARK-TIME
REG. U.S. PAT. OFF.
Timing Devices

M. H. RHODES, INC

MANUFACTURERS • HARTFORD 6, CONNECTICU


✓ MAKE-BEFORE-BREAK CONTACT
Action . . eliminates transfer "click" interferences or circuit interruptions.
✓ UNIQUE LAMINATED BRUSH TYPE CONTACTS
. . . Low and constant contact resistance.
DUNN INC SOCY

91XBX100 . . . . . DESIGNED FOR MICROPHONE AND THERMO-COUPLE SWITCHING CIRCUITS . . .

and other extremely low power control applications

The Struthers-Dunn a-c operated Type 91XBX100 Relay has double-pole double-throw, make-before-break contacts that are especially designed for handling milli-volt, milli-ampere, and milli-watt loads. Each moving contact consists of six laminations. The long sliding motion of the six contact surfaces results in extremely low and constant contact resistance, thus assuring electrically smooth performance—a "must" in audio frequency or recording instrument switching circuits.

The metal mounting plate acts as a shield, isolating the magnetic structure from the contacts, minimizing the possibility of induced a-c hum in the contact circuits.

Operating coils are available for use on standard voltages up to 230 volts a-c, 60 cycles.

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STRUTHERS-DUNN

5,312 RELAY TYPES

YOU'LL NEVER GET A KICK OUT OF THIS!

The man with the shotgun was plenty tired of the drubbing his shoulder took every time he fired. Then his dealer sold him a recoil pad of resilient Spongex* cellular rubber!

It was the old story of the thump and rattle and jar that wears on both product and owner . . . the cause of premature old age in products —from vacuum cleaners to automobiles. If you've been hunting for a shock absorbing material that will make your product vibration-free, more salable—think of Spongex.

The way it goes in and licks any number of tough product problems has spread its use into hundreds of applications for cushioning, sealing, insulation, sound dampening, gasketing, protection against dust, moisture, gases. Can be made in sheets, pads, slabs, cord, tubing, strips, molded forms and die-cut shapes.

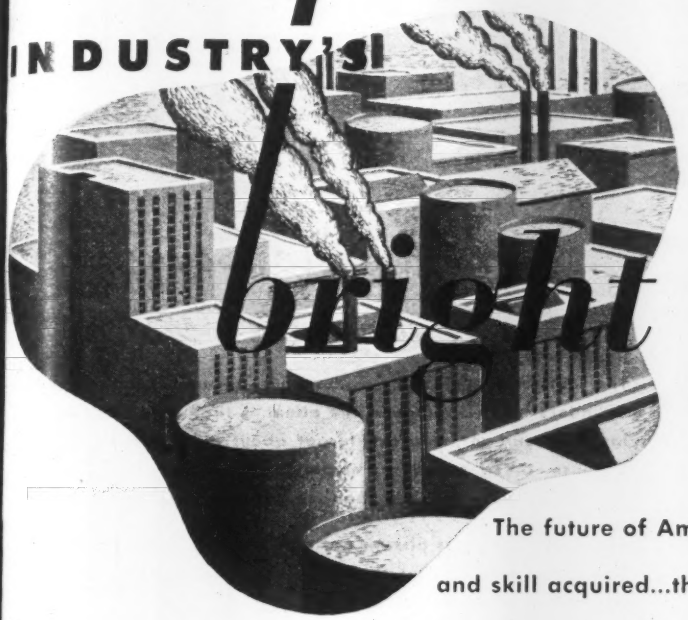
We are operating at peak capacity on industrial production and may not be able to produce what you need for some time—perhaps not until crude rubber is plentiful. However, if your need is urgent, write us and we shall try to help you. Sponge Rubber Products Company, 236 Derby Place, Shelton, Conn. Sales Offices: New York, Chicago, Detroit, Washington.

SRP

SPONGE RUBBER PRODUCTS CO.

SPONGEX* CELL-TITE* *TRADE MARK REG U.S. PAT. OFF. TEXLITE TEXLOCK

INDUSTRY'S



bright future...

The future of American industry is indeed bright...for the knowledge and skill acquired...the new and advanced methods of manufacture and production developed of necessity in the past few years are now available to manufacturers in all lines of activities.

Consolidated's line of vibration and strain measuring equipment proved its merit to the aircraft industry time and time again during the war period. Used under the most tortuous conditions by test pilots to seek out damaging strains and vibrations and to record their findings with unfailing accuracy, these instruments aided immeasurably in the production of America's superior air power.

Now, with the return to peacetime production, Consolidated offers its complete line of accelerometers, amplifiers, power supplies, vibration pick-ups and recording oscillographs to the automotive, railroad and construction industries and to all manufacturers who have need of these rugged, sensitive, accurate instruments with their wide range of application and great flexibility of operation.

Consolidated's advanced design, extensive development and precision manufacture, combined with its years of research in the field of sound wave studies and vibration measurements, may be of incalculable value to you. Consult our engineers about your requirements.

SPECIALIZING IN VIBRATION AND STRAIN MEASUREMENT

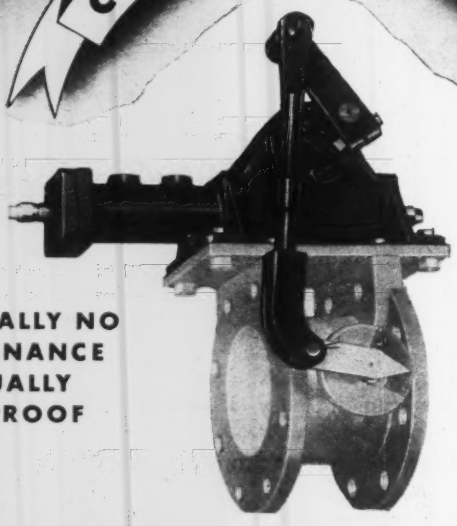
CONSOLIDATED ENGINEERING CORPORATION

620 NORTH LAKE AVENUE, PASADENA, CALIFORNIA

ASKANIA

CRANK-TYPE

HYDRAULIC CYLINDERS



PRACTICALLY NO MAINTENANCE
VIRTUALLY LEAK PROOF

A Flexible Source of Hydraulic Power

The outstanding feature concerning Askania Crank-Type Cylinders which engineers talk about is that once they are installed and set, you can forget about them! That's true because these cylinders, employing a rotary shaft, are inherently more oil-tight than the reciprocating type.

The ground ringless pistons not only provide almost friction-less operations . . . but they also keep maintenance at an irreducible minimum.

Bulletin 126 describes the characteristics of Askania Crank-Type Cylinders in detail. Write for your copy today.

ASKANIA REGULATOR CO.
A GENERAL PRECISION EQUIPMENT CORPORATION SUBSIDIARY
1605 S. MICHIGAN AVENUE, CHICAGO 16, ILLINOIS

Easy to Make Moisture Tests with a STEINLITE

Almost anyone can learn to operate the Steinlite in a short time. No special education or training is necessary. About all one does is (1) weigh out a sample, (2) pour it into the Steinlite hopper, (3) read a meter dial, and (4) compare the reading with a chart showing percentage of moisture.

HAVE YOU A MOISTURE TESTING PROBLEM?

If so, let us help you solve it with the Steinlite Electronic Moisture Tester . . . which tests a wide variety of products . . . grain, pop corn, nuts, cocoa, dehydrated eggs, carrots and many other products, and is constantly finding new applications. The fact that more Steinlites are in use than all other makes of electrically operated moisture testers indicates that industry recognizes the value of the Steinlite.

It is almost as easy to operate as a radio. No technical knowledge is required, and no previous experience. When used by an experienced operator it is "THE ONE MINUTE MOISTURE TESTER". Built by a pioneer organization of radio engineers . . . operates on the radio frequency impedance principle and is calibrated against official oven methods. Sold on FREE TRIAL basis. No money down. $325.00 F.O.B. Atchison, Kansas.

644 Brooks Building Chicago 6, Illinois

SEEDBURO EQUIPMENT COMPANY

Must we go back?

The evolution of electronics will always remain a bright page in the history books of science. And the record has been significantly brilliant during the past four years when improvements and developments were advanced at a faster rate than normal. With the ending of the war, there may be a few who do not feel the urgency to progress at a similar pace . . . who will be willing to relax the rigid wartime standards. Or there may be those who do not too accurately gauge the temper of the consumer, now in a mood to anticipate only the best from an industry which has accomplished such miracles in the past few years.

Along with many other far-sighted producers, we here at Marion fully intend to maintain our wartime quality pattern, and to cooperate in every known way to provide even better products for a peaceful world. We endorse the postwar standardization program of the Army and Navy Electronics Standards Agency, and will continue to manufacture all Marion electrical indicating instruments in conformity with JAN specifications. Our customers have a right to expect nothing else.

It is important to note that continued adherence to the Electronics Standards Agency program need not result in increased costs, either to the manufacturer or the consumer . . . while it will definitely result in improved product performance wherever such standardized components are used.

We, the manufacturers, engineers, consumers of electronics, are part of a vital, daring, visionary industry. It is with this realization that we are faced with the responsibility of deciding, at this time, whether we can relax, or whether we shouldn't give as much to a world at peace as we gave to a world at war.

Your comments will be welcomed.

MARION ELECTRICAL INSTRUMENT CO.
MANCHESTER, NEW HAMPSHIRE
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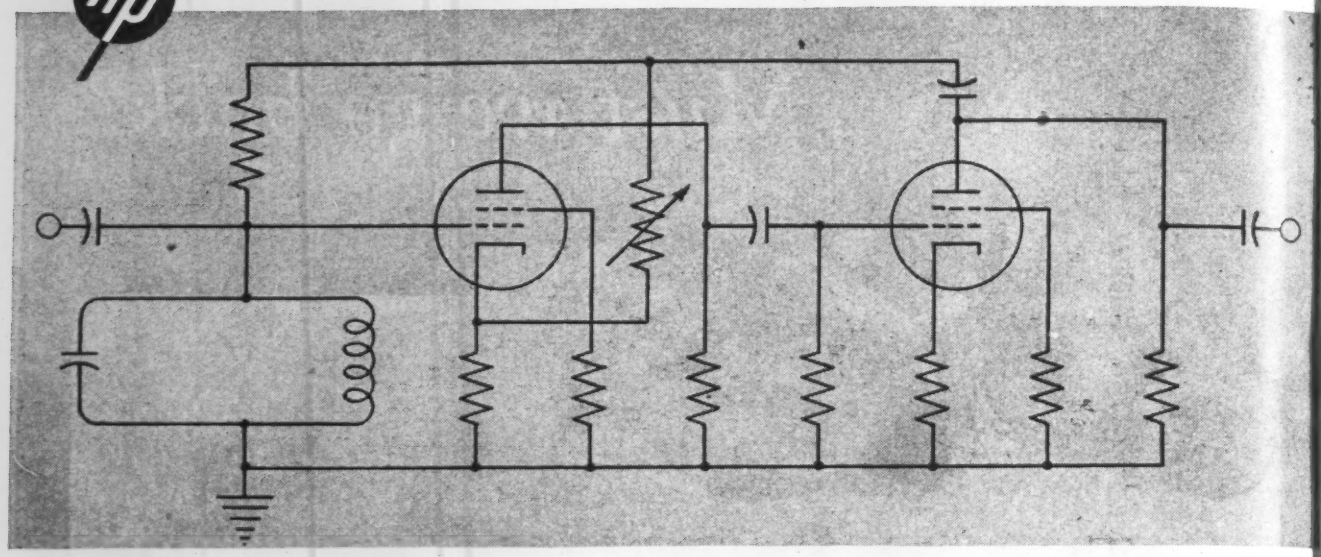
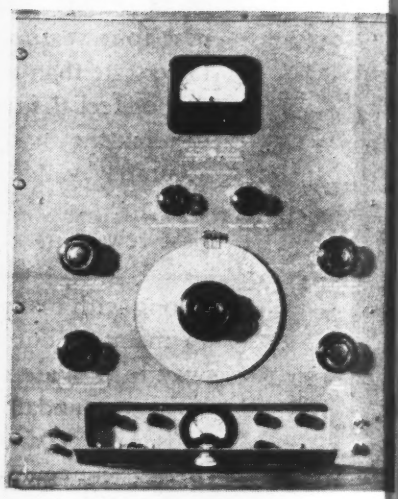
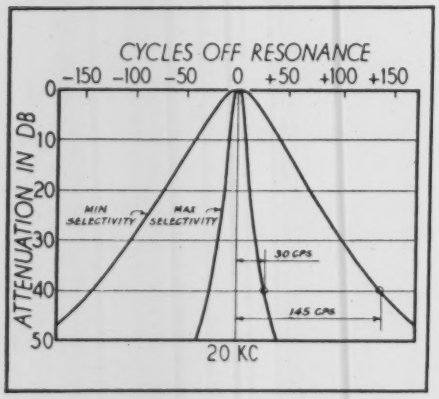
LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY



The High—and Variable "Q" of This Circuit Means Rapid, Accurate Wave Analysis



This -*hp*- Harmonic Wave Analyzer measures the individual components of complex waves with speed and surety, because of the highly efficient composite circuit shown above. The variable selectivity of the amplifier is the factor which makes it especially useful for measurements at higher frequencies. Regeneration is used to give the amplifier a high effective "Q," and a degeneration control provides variable selectivity. The resulting performance of this circuit is shown in accompanying graph.



In practical terms, variable selectivity means no tedious "searching out" of the harmonics to be measured. Yet the fingertip control is easy to manage. This characteristic makes the -*hp*- Harmonic Wave Analyzer useful for many applications where constant selectivity would be unsuitable. Variable selectivity is required in measuring distortion of sound on recorded film, disks and other cases where there may be a small amount of frequency modulation. It is also used in integrating the noise spectrum in acoustic measurements and elsewhere when a wider pass band gives a more representative integration.

The -*hp*- Harmonic Wave Analyzer covers the audio spectrum from 30 to 16,000 cps. There is likewise a wide voltage range; full scale voltmeter readings may be obtained with inputs of .001 to 500 volts. Thus the 300A may be used with equal success with low output recording devices and high power modulating amplifiers. Other features which make it unexcelled for both laboratory and production testing are the linear meter scale, fully protected against overloads, and the built-in calibrating system to standardize voltage measurements. With the stability, accuracy, flexibility and ease of operation of the Harmonic Wave Analyzer, Hewlett-Packard continues to set a new standard. 1119

These -hp- Representatives Are at Your Service

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Audio Frequency Oscillators *Signal Generators* *Vacuum Tube Voltmeters*
Noise and Distortion Analyzers *Wave Analyzers* *Frequency Meters*
Square Wave Generators *Frequency Standards* *Attenuators* *Electronic Tachometers*

TYPICAL

Cyclograph

100%

QUALITY TESTING

Non-destructive testing of machinability of metal stock to be machined in automatic high-speed equipment.

•

Inspecting iron castings for machinability.

•

Inspecting mixed lots of forged steel.

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Inspecting 150,000 pounds of packaged welding electrodes according to analysis, without opening the packages.

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Automatically sorting six and a half million copper-clad steel cups to discard those accidentally reversed in the stamp.

•

Sorting large quantities of mixed bolts according to their SAE analyses.

•

Checking gears for case depth.

•

100% quality inspection and control of incoming materials and outgoing products according to metallurgical analyses, case depth, depth of decarburization, amount of cold working, brittleness (stress gradients), structure, etc., in either non-ferrous or ferrous metals.

100%

QUALITY INSPECTION

No chain is stronger than its weakest link. By the same token, no product is better than the quality of its component parts. Whether your parts are castings, forgings, or products machined from bar stock—bolts, screws or finished products—ferrous or non-ferrous, the Cyclograph may prove of invaluable assistance in speeding up or maintaining production. The

DuMONT *Cyclograph*

manned by semi-skilled workers, performs metallurgical tests that uphold high standards of quality according to predetermined values. And it performs these tests *non-destructively* and instantaneously!

Submit your problem . . .

● Our Materials Test Division is prepared to study your production quality control requirements. Available literature includes the Metal Testing Questionnaire which will assist you in compiling the data necessary for OUR study of YOUR problem. Preliminary tests performed without obligation.

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DUMONT *Precision Electronics & Television*

ALLEN B. DuMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

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LOW FREQUENCIES ACCURACY TO 1/1,000th of 1%

TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

American Time Products, Inc.

580 Fifth Ave. **New York, N. Y.**

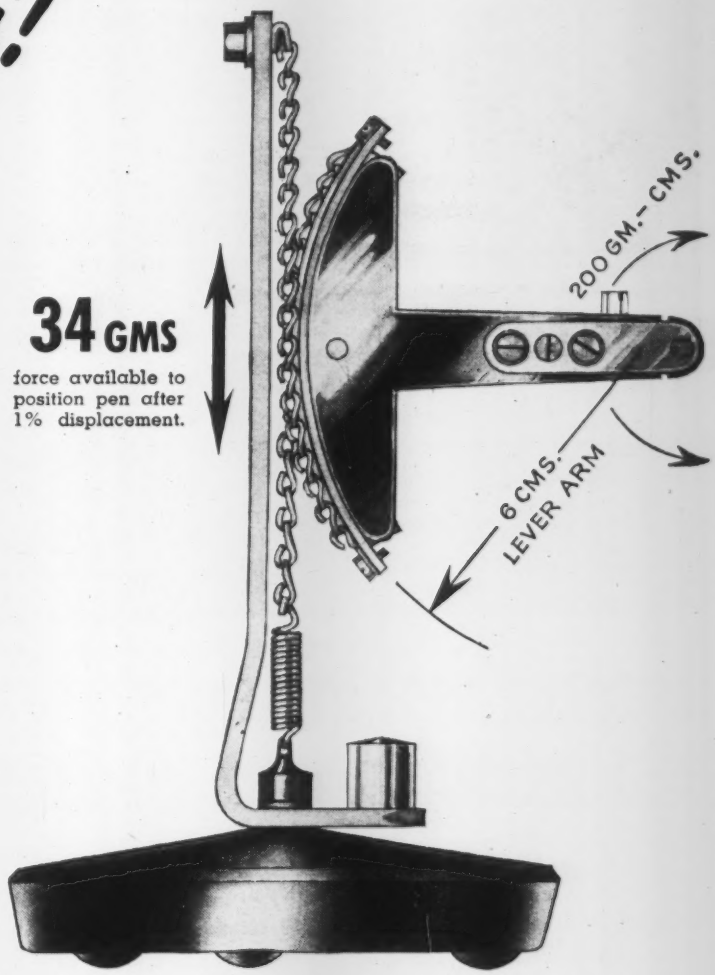
Dist. of Western Electric & *Watch Master* Watch-rate Recorders

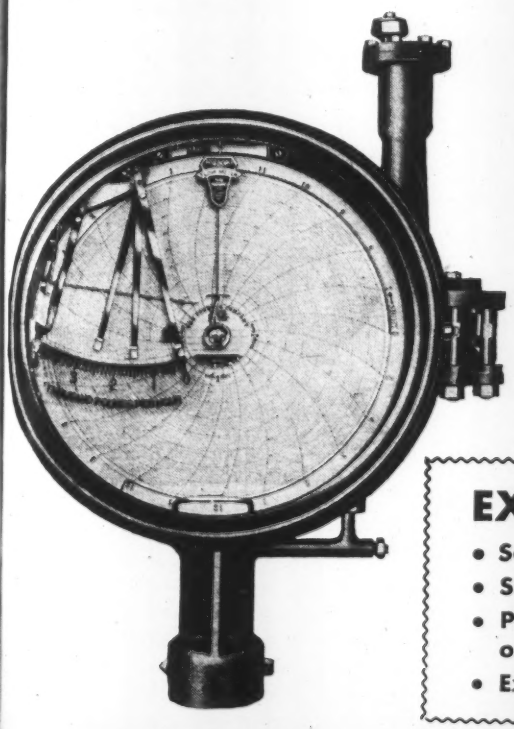
Here's FLOAT POWER ...and no foolin'!

Driving torque of over 200 gm.-cms. forces accuracy in Foxboro Meter Records, despite dirt or scale.

It's typical of Foxboro's *better-engineering-to-the-last-detail* that Foxboro Flow Meters have extra-large floats with extra-long travel. This exclusive feature gives nearly double the power to prevent frictional inaccuracies. For example, in Type 4 and Type 8 Foxboro Meters, it provides pen torque of more than 200 gram-centimeters with a float displacement of only 1% of scale range.

Foxboro Flow Meters cost no more than other meters of the same type. Yet their rugged, better-engineered design means important extra values . . . easier installation . . . simpler, less-frequent servicing . . . positive saving of mercury . . . unvarying accuracy throughout years of use.





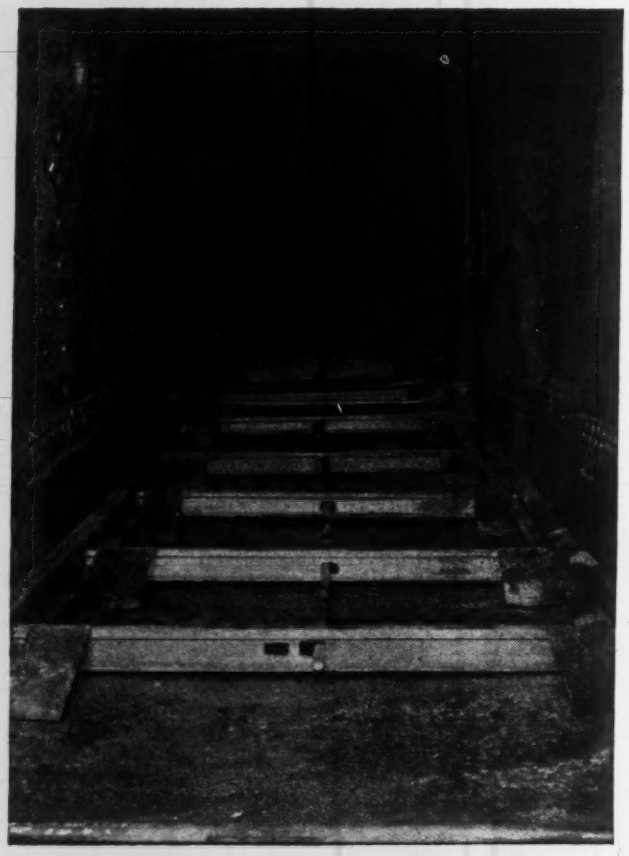
New Bulletin 200-7 gives detailed information on the extra-value features of Foxboro Meters for all pressures up to 5,000 lbs. Write for your copy. **The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U. S. A.** Branches in principal cities.

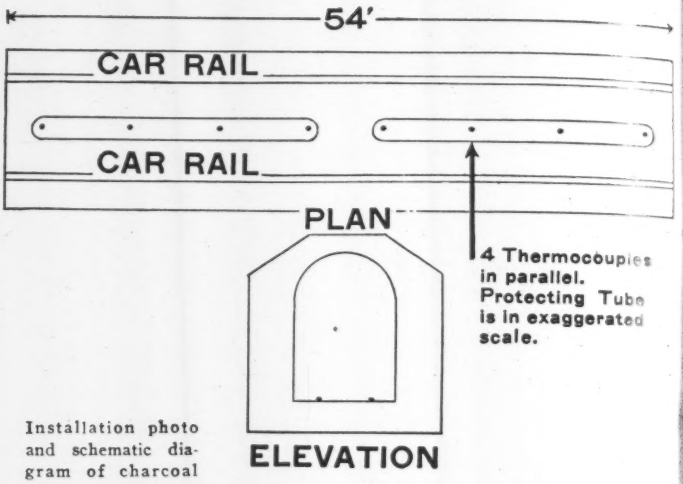
EXCLUSIVE FOXBORO REFINEMENTS

- **Segmental Lever Transmission gives straight-line calibration.**
- **Sure-Seal Check Valves positively prevent mercury losses.**
- **Pressur-Tite Bearing eliminates friction of stuffing boxes or multiplication for flexure or torque tubes.**
- **Extra-large Float with long travel gives extra power.**

FOXBORO REG. U. S. PAT. OFF.

MONEY-SAVING FLOW METERS





Installation photo and schematic diagram of charcoal retort at Cliffs-Dow Chemical Co., Marquette, Mich. The thermocouples report average temperature to the Micromax Recorder on firing floor.

AVERAGE RETORT TEMPERATURE . . .
As MICROMAX Records It for Cliffs-Dow

For the Cliffs-Dow Chemical Co., makers of charcoal and its by-products, the *average* temperature inside a retort provides a better operating guide than does the "smoke neck" or outlet gas temperature. And with 11 Micromax Recorders, serving 22 charcoal retorts, *average* temperature is just what the Company gets. Here's how it's done:

In each retort, three temperature measurements are made by the Micromax instrument. Two of these are averages, detected at each end of the retort by thermocouples arranged as shown above. The third point recorded is the flue gas temperature, detected by a single couple. Guided by these highly accurate readings, operators can control more closely the temperatures of the retorts and of the flue gas-and-air mixture that goes to the predriers. Both quantity and quality of product output are improved as a result.

Micromax's easy maintenance scores another point in its favor. The Recorder is sturdy and compact; couples can be replaced, even while retort is in operation, without disturbing the calibrating of the Micromax.

Our Catalog N-33A, describing Micromax Recorders, will be sent on request, or an L&N engineer will gladly work with you on a specific temperature problem, if you prefer.

The 6-point Micromax Recorder, by keeping a consistently accurate tab on retort temperature during the 16- to 24-hour firing cycle, helps Cliffs-Dow manufacture more efficiently such products as Cliffchar granular charcoal (pictured), Cliffchar lump charcoal, acetic acid, methanol, creosote, etc.

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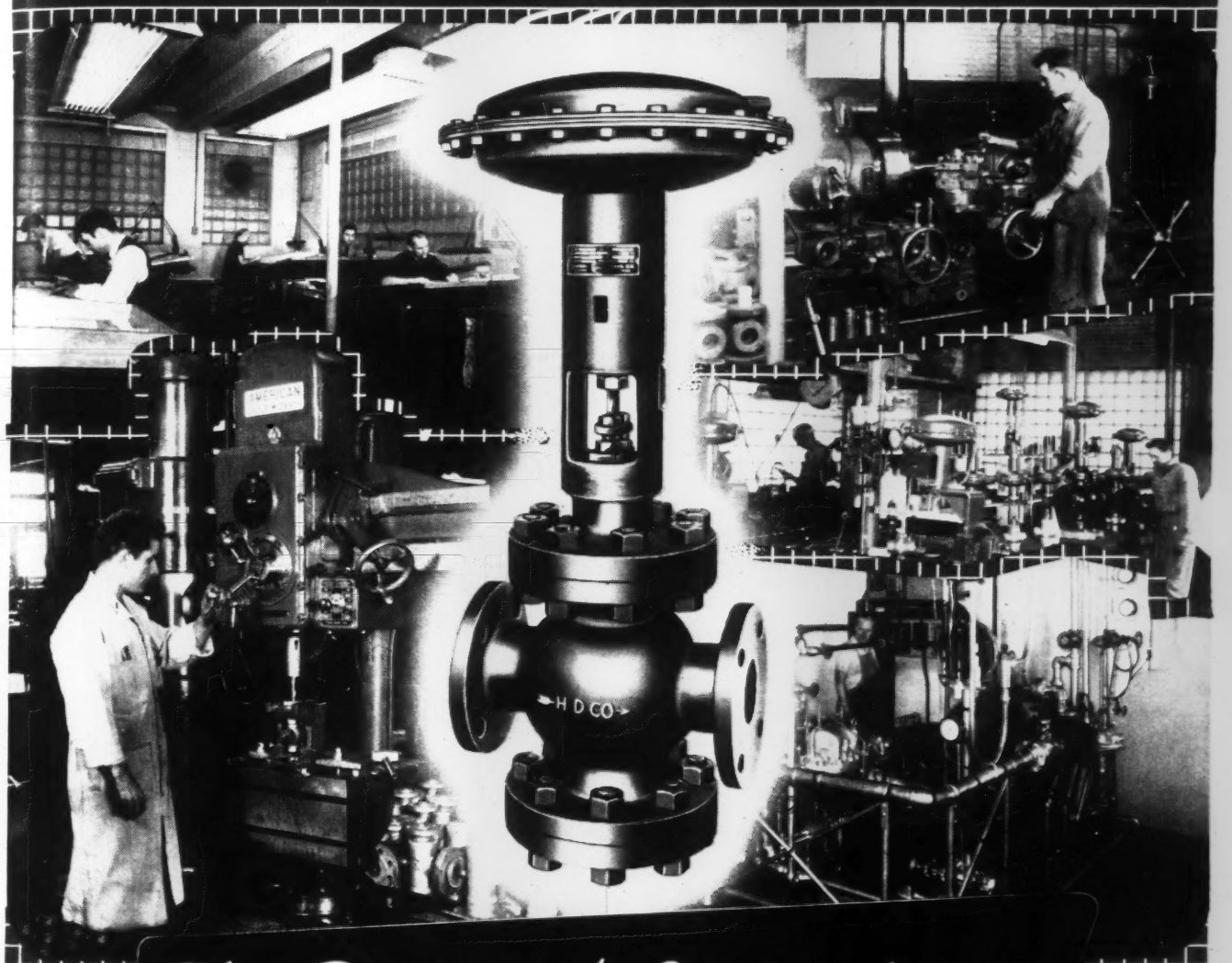
AUTOMATIC CONTROL EQUIPMENT

ENGINEERED DESIGN BY **HAMMEL-DAHL**



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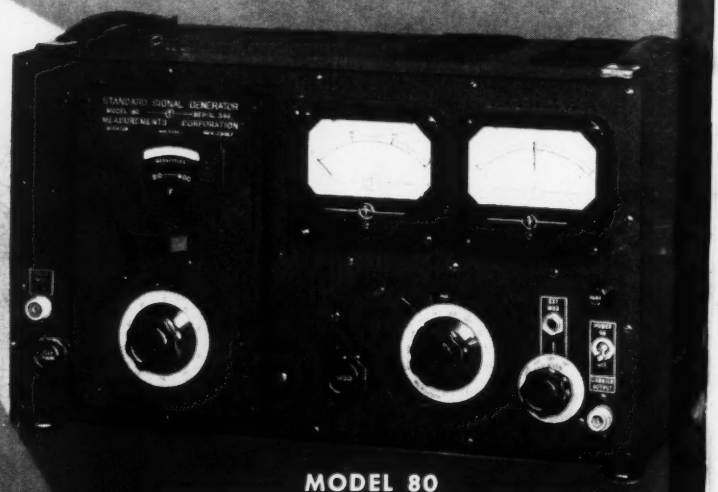

MODEL 80
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2 to 400 megacycles
AM and Pulse Modulation

MODEL 62
VACUUM TUBE VOLTMETER
0 to 100 volts AC, DC and RF

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